UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

September 14, 2000

MEMORANDUM

SUBJECT: Malathion: Revised Occupational and Residential Exposure and Risk Assessment for the Reregistration Elegibility Decision (RED) Document.

FROM: Jack Arthur, Environmental Scientist
Registration Action Branch 3
Health Effects Division (7509C)

THRU: Steve Dapson, Branch Senior Scientist
Registration Action Branch 3
Health Effects Division (7509C)

TO: Paula A. Deschamp, Biologist
Reregistration Branch 2
Health Effects Division (7509C)

The revised occupational/residential exposure assessment for the HED RED Chapter for malathion is attached. The previous version of this document is dated April 26, 2000. This current document has been revised to reflect public comments specifically addressing the occupational/residential exposure and risk assessment. Comments were submitted by the following:

- Wisconsin Strategic Pesticide Information Project
- American Nursery and Landscape Association
- Oregon Strawberry, Blueberry, Raspberry and Blackberry Commissions
- Jellinek, Schwartz & Connolly, Inc., in behalf of Cheminova A/S
- US Department of Agriculture's Animal and Plant Health Inspection Service
- The Scotts Company
- Mint Industry Research Council
- New Jersey Environmental Federation
- Knouse Foods
- Centers for Disease Control
- Private Citizen (Pascarella)
- Natural Resources Defense Council

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MALATHION
OCCUPATIONAL AND RESIDENTIAL EXPOSURE CHAPTER

1.1 Purpose

In this document, which is for use in EPA's development of the Malathion Reregistration Eligibility Decision Document (RED), HED presents the results of its review of the potential human health effects of occupational and residential exposure to malathion. This particular RED includes primarily those product formulations, agricultural and non-agricultural use sites supported by the basic producer (Cheminova) and IR-4 and listed in a 2/17/98 Agency Memorandum.

1.2 Criteria for Conducting Exposure Assessments

An occupational and/or residential exposure assessment is required for an active ingredient if (1) certain toxicological criteria are triggered and (2) there is potential exposure to handlers (mixers, loaders, applicators, etc.) during use or to persons entering treated sites after application is complete. For malathion, both criteria are met.

1.3 Summary of Toxicity Concerns Relating to Occupational and Residential Exposures

1.3.1 Acute Toxicity Categories

The toxicological data base for malathion [S-1,2-bis (ethoxycarbonyl)ethyl O,O-dimethyl phosphorodithioate] is adequate and will support reregistration. Table 1 summarizes the acute toxicity values and categories for technical (97%) malathion.

Table 1: Acute Toxicity Categories for Technical Malathion

Test	Results	Toxicity Category
Acute Oral - Rat	LD_{50} = 5400 mg/kg/day ♂ 5700 mg/kg/day ♀	IV
Acute Dermal - Rat	LD_{50} = >2000 mg/kg/day ♀♂	III
Acute Inhalation - Rat	LC_{50} = >5.2 mg/L ♀♂	IV
Primary Eye Irritation - Rabbit	Slight conjunctival irritation; cleared by 7 days	III
Primary Dermal Skin Irritation - Rabbit	Slight dermal irritation (PIS = 1.1)	IV
Dermal Sensitization - Guinea Pig	Not dermally sensitizing	--

Toxicity Category III for acute dermal toxicity requires an interim 12-hour restricted entry interval (REI) for agricultural workers under the Worker Protection Standard.

1.3.2 Other Endpoints of Concern

The HED Hazard Identification Assessment Review Committee (HIARC) report on malathion, dated December 17, 1997 (revised by HIARC report dated August 31, 2000), indicates there are toxicological endpoints of concern for malathion. See Table 2.

Table 2: Endpoints for Assessing Occupational and Residential Risk for Malathion

Exposure Duration/Scenario	NOAEL for use in Risk Assessment	Target MOE
Acute Dietary Exposure	**50 mg/kg/day** The selected NOAEL is from a rabbit developmental study where maternal toxicity (anorexia) resulted from multiple doses.	100
Chronic Dietary Exposure	**2.4 mg/kg/day** The selected NOAEL is from a 2-year rat feeding study. Effect is inhibition of plasma cholinesterase.	100
Short-term Dermal Exposure (1-7 days) Intermediate-Term Dermal Exposure (1 week to several months)	**50 mg/kg/day** Since the selected NOAEL is from a 21-day dermal rabbit toxicity study, the use of a dermal absorption factor is not necessary. Effect is inhibition of plasma, RBC and brain cholinesterase activity.	100
Long-term Dermal Exposure	**2.4 mg/kg/day** Since the selected NOAEL is from a 2-year rat feeding study, a 10% dermal absorption factor is used to calculate a dermal equivalent dose. Effect is inhibition of plasma cholinesterase.	100
Inhalation Exposure (Short-, Intermediate- and Long-term Exposure Scenarios)	**25.8 mg/kg/day** The inhalation LOAEL of 0.1 mg/L was converted to 25.8 mg/kg/day. A 100 percent inhalation absorption factor is implicit in these estimations. Effect is histopathology in respiratory epithelium.	1000 See details below
Carcinogenicity	In accordance with the EPA *Proposed Guidelines for Carcinogen Risk Assessment* (July 1999), the Cancer Assessment Review Committee at the 12-April-2000 meeting, classified malathion as **"suggestive evidence of carcinogenicity but not sufficient to assess human carcinogenic potential"** by all routes of exposure.	**Quantitative risk assessment for carcinogenicity is NOT required** since the Committee classified malathion as having suggestive evidence for cancer. A cancer dose-response assessment, e.g., a low dose linear extrapolation model, is not indicated for pesticides in the "suggestive"category.
Aggregate Assessment*	The dermal and inhalation MOEs may be combined to obtain a total MOE since a common toxicological endpoint (cholinesterase inhibition) was observed.	Total MOE approach used for cholinesterase effects

* For inhalation exposure, a LOAEL of 0.1 mg/L (i.e., 25.8 mg/kg/day) was selected. The committee recommended that an MOE of 1000 be applied to short-term, intermediate-term and chronic inhalation risk assessments (includes the conventional 100 and an additional 10X for the use of a LOAEL and the severity of the nasal lesions observed in the two-week range finding study). For dermal exposure, cholinesterase inhibition was selected (NOAEL of 50 mg/kg/day). Since cholinesterase inhibition is also seen from inhalation exposure(albeit, a relatively insignificant contributing factor), the MOEs from this route (using a NOAEL of 25.8 mg/kg/day) were also combined with the MOEs for dermal exposure to give an indication of cholinesterase inhibition from both routes. [It is important to note that dermal exposure drives the risk for cholinesterase inhibition]

1.4 Incidents Reports (Appear in separate document)

1.5 Summary of Use Patterns and Formulations

1.5.1 Occupational-Use and Homeowner-Use Products

At this time, products containing the insecticide, malathion, are intended for both occupational and residential uses. Occupational uses include terrestrial food and feed crops, indoor food crops, terrestrial non-food crops, and general wide-area treatments for mosquito vector control. There are outdoor residential uses of malathion which include vegetable gardens, home orchards, ornamentals and lawns.

1.5.2 Type of pesticide/targeted pests

Malathion [S-1,2-bis (ethoxycarbonyl)ethyl O,O-dimethyl phosphorodithioate] is an organophosphate insecticide. Examples of the type of pests that malathion is used to control include (but are not limited to) the following:

- Aphids, Japanese beetles, leafhoppers, spider mites, thrips, onion maggots, armyworms, weevils, spittlebugs, lygus bugs, drosphilia, grasshoppers, lacebugs, blister beetles, and whiteflies on agricultural crops (e.g., fruits and nuts, field crops, and vegetables), homeowner fruit trees, homeowner vegetable/small fruit gardens.

- Ants, aphids, cabbage worms, crickets, spider mites, Japanese beetles, grasshoppers, red banded leaf-rollers, spittle bugs, bag worms, wax scale, greenscale, tent caterpillars, ground pearls, imported fire ants, millipedes, sawbugs, and springtails on turf.

- Aphids, spider mites, lace bugs, tent caterpillars, pine needle scale, pine needle sheath miners, red-headed pine sawfly, wax scale, oak kermes on ornamentals (e.g., flowers, shade trees, shrubs, and forest trees).

- Mosquitoes for public health.

- Boll weevil (USDA Boll Weevil Eradication Program).

1.5.3 Formulation types and percent active ingredient

Based on a 12/97 review of OPP Reference Files System (REFS), there are active registrations for 256 products containing malathion. Malathion is formulated as a technical (91-95% ai), a dust (1-10%, an emulsifiable concentrate (3-82% ai), a ready-to-use (1.5-95% ai), a pressurized liquid (0.5-3% ai), and a wettable powder (6-50% ai). Several of the 95% liquids are intended for Ultra-Low-Volume (ULV) applications.

For the purposes of generating this Occupational/Residential Science Chapter, the exposure/risk assessment presented here is based, in part, on the sites and use patterns on representative product labels registered to the basic producer, Cheminova. When end-use product DCIs are developed (e.g., at issuance of the RED), the Registration Division should require that all end-use product labels (e.g., MAI labels, SLNs, and products subject to the generic data exemption) be amended such that they are consistent with the basic producer labels.

1.5.4 Registered Use sites

Occupational-use sites. Malathion is registered for occupational-use on terrestrial food and feed crops, indoor food crops, aquatic food crops, terrestrial non-food crops, forestry, indoor non-food, and indoor and outdoor residential. The specific occupational use sites in this RED are seen below, with agricultural crops grouped according to the Code of Federal Regulations 40 Part 180. To make such a large number of use sites manageable, some of the use sites seen below were re-grouped in the assessment tables according to type of crop and application rates in a way that is believed to bracket the exposures and risks.

- **Root and Tuber Vegetables,** including beets (garden), carrots, chayote root, horseradish, parsnip, potatoes, radish, rutabaga, salsify, sweet potatoes, turnip and yams;
- **Bulb Vegetables**, including garlic, leeks, onion (bulb and green), shallots;
- **Leafy Vegetables (except Brassica)**, including celery, dandelion, endive (escarole), lettuce (head and leaf), parsley, spinach and Swiss chard;
- **Brassica Vegetables**, including broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, collards, kale, kohlrabi and mustard greens;
- **Legume Vegetables**, including peas (dried and succulent);
- **Fruiting Vegetables (except Cucurbits)**, including eggplant, peppers, tomatoes and tomatillo;
- **Cucurbit Vegetables**, including chayote fruit, cantaloupe, cucumber, melon, pumpkin, squash (summer and winter) and watermelon;
- **Citrus Fruits**, including grapefruit, kumquat, lemon, lime, orange, tangelo and tangerines;
- **Pome Fruits**, including apples, pear and quince;
- **Stone Fruits**, including apricots, cherries (sweet and tart), nectarines and peaches;
- **Berries**, including blackberries, boysenberries, dewberries, raspberries, strawberries, blueberries and loganberries;
- **Tree nuts**, including chestnut, macadamia, pecans and walnuts;
- **Cereal Grains**, including barley, corn (field, sweet and pop), oats, rice, rye, sorghum grain, wheat (spring and winter) and wild rice;
- **Grass Forage, Fodder, and Hay Group**, including grasses;
- **Nongrass Animal Feeds**, including alfalfa, clover, lespedeza, lupin, and vetch;
- **Pineapples**

- **Cotton**
- **Grapes**
- **Flax**
- **Hops**
- **Mango**
- **Mint**
- **Okra**
- **Papaya**
- **Watercress**
- **Turf**, including turf in parks, pastures, sod farms, and golf courses.
- **ULV Agricultural Crops**, including the aforementioned crops sprayed in ultra low volume over large land areas.
- **Ornamentals,** including flowers, shrubs, flowering plants, nursery stock, and woody plants.
- **Pine Trees,** including pine seed orchards, Christmas tree plantations, slash pine plantations, shrubs, shade trees, and forest trees.
- **Mosquitoes,** including fruit flies, and other swarming flying insects sprayed/fogged over large land areas.
- **ULV Mosquitoes**, including flies, and other swarming flying insects sprayed/fogged in ultra low volumes over large land areas.
- **Grape Root Dip**, including the process of dipping grape roots.
- **Storage Grain Facility**, including stored commodities such as corn, wheat, barley, oats, and rye.
- **Agricultural Premises,** including agricultural premises outside barns, applied as a bait only.
- **Mushrooms,** including mushrooms in mushroom houses.

It should be noted that the Agency has been informed by the producer (Cheminova) and IR4 that the following occupational use sites will not be supported for reregistration:

- All pet uses for all formulations;
- All livestock uses with all formulations;

- All indoor uses (except stored commodities and storage facilities);
- All greenhouse uses (except that mushroom use is presumed to be in mushroom houses for purposes of this assessment);
- All open-forest uses;
- All seed treatments with all formulations;
- All formulations for the following uses:
  - Almonds (including hulls and shells)
  - Cranberries
  - Filberts
  - Peanuts (including forage, hay, storage and storage facilities)
  - Peavines (including hay)
  - Safflower seed
  - Soybeans (including hay and forage)
  - Sugar beets
  - Sunflower seed
  - Treated raisin trays
- All pressurized can formulations.

Consequently, most of these use sites, while they may be included in the list of currently registered uses, have not been specifically included in the occupational exposure/risk assessment in this RED document.

Non-occupational (Residential) Use Sites. Potential residential and non-occupational use sites may include outdoor residential sites (e.g., use on ornamentals, lawns and vegetable gardens), professional uses at residential sites, and professional sites where non-occupational exposure may occur (exposure to treated ornamentals in parks, residential, and recreational areas, and exposure to treated trees in Christmas-tree plantations and pine forests). For ease and brevity, the non-occupational crops use sites in this RED have been grouped as follows:

- **Homeowner fruits and nuts,** including apples, cherries, grapes, peaches, plums, strawberries, oranges and tangerines.

- **Homeowner turf**.

- **Homeowner vegetables,** including beans, beets, broccoli, cabbage, collards, cucumbers, melons, tomatoes, peas and peppers.

- **Homeowner outdoor premise treatments**, including the perimeter of kennels and other residential structures.

- **Ornamentals at residences and within residential areas** (parks, recreation areas, etc.), including shade trees, evergreens, and roses.

1.5.5 Application rates

A policy decision was made to use the maximum application rates from residue field trials in support of food tolerances for the assessment of all agricultural uses. This decision was based on a statetment by the registrant of its intention to only support these agricultural use rates for the reregistration of malathion. The maximum label rates were used for all non-agricultural uses. Application rates (in lb ai/acre, unless otherwise specified) used for each formulation in the assessment are listed below:

- **Root and Tuber Vegetables:** 1.56 for EC
- **Bulb Vegetables:** 1.56 for EC
- **Leafy Vegetables (except Brassica):** 2.0 for EC
- **Brassica Vegetables:** 1.25 for EC
- **Legume Vegetables:** 2.5 for EC; 0.61 for ULV
- **Fruiting Vegetables (except Cucurbits):** range 1.56 - 3.43 for EC
- **Cucurbit Vegetables:** 1.88 for EC
- **Citrus Fruits:** 6.25 for EC; 0.175 for ULV
- **Pome Fruits:** 1.25 for EC
- **Stone Fruits:** 3.75 for EC; 1.22 for ULV
- **Berries:** 2.0 for EC and WP; 0.76 for ULV
- **Tree nuts:** 5.0 for EC
- **Cereal Grains:** 1.25 for EC; 0.61 for ULV
- **Grass Forage, Fodder, and Hay Group:** 1.25 for EC; 0.92 for ULV
- **Nongrass Animal Feeds:** 1.25 for EC; 0.61 for ULV
- **Pineapples**: 5.0 for EC
- **Cotton:** 2.5 for EC; 1.22 for ULV and RTU
- **Grapes:** 1.88 for EC
- **Flax:** 0.5 for EC
- **Hops:** 0.63 for EC
- **Mango:** 1.25 for EC
- **Mint:** 0.94 for EC
- **Okra:** 1.5 for EC
- **Papaya:** 1.25 for EC
- **Watercress:** 1.25 for EC
- **Dates:** 4.24 for dusts

- **Turf:** The maximum application rate for turf is 8.7 lbs ai per acre.

- **Ornamentals and Pine Trees:** The maximum application rate for ornamentals and trees is 2.5 lbs ai per acre.

- **Mosquitoes:** The maximum application rate for mosquitoes is 0.5 lbs ai per acre.

- **ULV Mosquitoes:** The maximum application rate for a ground fogger ULV application is 0.11 lb ai/A, and for an aerial ULV application, 0.23 lb ai/A. These are maximum use rates from the major producers label (i.e., Cheminova's FYFANON® ULV).

- **Grape Root Dip:** The maximum application rate for dipping grape roots is 1.9 lb ai per 100 gallons.

- **Storage Grain Facility:** The maximum application rate for stored grain such as corn, wheat, barley, oats and rye is 0.3 lbs ai per 1,000 square feet.

- **Agricultural Premises:** The maximum application rate for agricultural premises is 0.27 lb/gal.

- **Mushrooms:** The maximum application rate for mushrooms is 0.039 lb ai/1,000 square feet.

- **Homeowner Fruit Trees:** The maximum application rate for homeowner fruits is 0.034 lb ai/gallon.

- **Homeowner Ornamentals:** The maximum application rate for homeowner ornamentals is 0.034 lb ai/gallon.

- **Homeowner Turf:** The maximum application rate for homeowner turf is 0.18 lb ai/1000 sq. feet.

- **Homeowner Vegetable:** The maximum application rate for homeowner vegetables is 0.023 lb ai/gal.

- **Homeowner Mosquito and Other Household Pest Applications:** The maximum application rate for applying to mosquitoes and other household pests as a spray in a residential setting is 0.1547 lb ai/gal. The maximum application rate for applying to mosquitoes as a fogger in a residential setting is 0.012 lb ai/gal.

1.5.6 Methods and Types of Equipment Used for Mixing, Loading, and Application

- **Agricultural Crops:** Equipment for commercial use is groundboom sprayer, fixed-wing aircraft, chemigation equipment, helicopter, and airblast sprayer.

- **ULV Agricultural Crops:** Equipment for commercial use is fixed wing aircraft and helicopters.

- **Turf:** Equipment for commercial use is groundboom sprayer, fixed-wing aircraft, helicopter, low pressure handwand, backpack sprayer, hose end sprayer and turf handgun.

- **Ornamentals and Pine Trees:** Equipment for commercial use is groundboom equipment, chemigation equipment, fixed wing aircraft, airblast sprayer, helicopter, low pressure handwand, and backpack sprayer.

- **Mosquitoes:** Equipment for commercial use is fixed wing aircraft, helicopter, fogger, and paintbrush.

- **ULV Mosquitoes:** Equipment for commercial use is fixed wing aircraft, helicopter, and fogger.

- **Grape Root Dip:** Hand-dipped or semi-automated in racks.

- **Stored Grain Facility:** Equipment for commercial use includes a fixed sprayer and power duster for grain treatment and handheld sprayer for empty bin treatment.

- **Agricultural Premises:** Equipment for commercial use includes a low pressure handwand, and backpack sprayer.

- **Mushrooms:** Equipment for commercial use includes a hose end sprayer.

- **Homeowner Fruit Trees:** Equipment for residential use includes a low pressure handwand, hose end sprayer, and backpack sprayer.

- **Homeowner Ornamentals:** Equipment for residential use includes a low pressure handwand, hose end sprayer, backpack sprayer, and a shaker can.

- **Homeowner Turf:** Equipment for residential use includes a low pressure handwand, hose end sprayer, backpack sprayer and a shaker can.

- **Homeowner Vegetable:** Equipment for residential use includes a low pressure handwand, hose end sprayer, backpack sprayer, and a shaker can.

- **Homeowner Mosquito Applications:** Equipment for residential use includes a low pressure handwand, hose end sprayer, backpack sprayer, fogger, and a shaker can.

1.5.7 Timing and Frequency of Applications -

- **Agricultural Crops:** Repeat as necessary. Observe pre-harvest intervals, most of which are 1, 3, 7 or 14 days, depending upon the crop.

- **Turf:** Repeat as necessary.

- **Ornamentals and Pine Trees:** Repeat as necessary.

- **Mosquitoes:** Repeat as necessary.

- **ULV Mosquitoes:** Repeat as necessary.

- **Grape Root Dip:** Assumed one treatment of nursery stock vines during winter season.

- **Stored Grain Facility:** For grain bin, after facility has been swept clean; as often as necessary. One treatment of grain (as it is going into storage); good for up to one year of storage.

- **Agricultural Premises:** As needed at approximately 2-week intervals.

- **Mushrooms:** Apply immediately after harvest and repeat twice per week as needed.

- **Homeowner Fruit Trees:** Typical applications are made when new spring growth for flowering begins. Repeat at 7-10 day intervals. A maximum number of applications or seasonal use rate has not been established.

- **Homeowner Ornamentals:** Apply when insects are present and repeat as necessary.

- **Homeowner Turf:** Repeat at 3 or 4 weeks, if necessary.

- **Homeowner Vegetable:** Apply one or more full coverage spray as needed.

- **Homeowner Mosquito Applications:** Apply as needed at 7-day intervals for residual adult mosquito control. Household insects: apply to lawns and a 10 foot wide stip along

side of house at 7-day intervals, as needed. Fogging machines are recommended to be used at dusk, with repeat applications as necessary.

2.0 OCCUPATIONAL EXPOSURES AND RISKS

2.1 Handler Exposures and Risks

EPA has determined that there are potential exposures to mixers, loaders, applicators, and other handlers during usual use-patterns associated with malathion.

2.1.1 Handler Exposure Scenarios

Based on the above listed use patterns which were developed from current labels, several major occupational exposure scenarios were identified for malathion:

(1a) mixing/loading liquids for groundboom application;
(1b) mixing/loading liquids for aerial and chemigation application;
(1c) mixing/loading liquids for airblast sprayer;
(1d) mixing/loading liquids for dipping;
(1e) mixing/loading liquids for a fogger;
(1f) mixing/loading liquids for handgun;
(2) loading dusts for power duster or direct application;
(3a) mixing/loading wettable powders for groundboom application;
(3b) mixing/loading wettable powders for aerial application;
(3c) mixing/loading wettable powders for airblast sprayer;
(4) applying sprays with an airblast sprayer;
(5) applying sprays with a groundboom sprayer;
(6) applying sprays with a fixed-wing aircraft (also covers use of helicopter application);
(7) applying sprays with a fogger;
(8) applying dusts with a power duster;
(9) dipping plants;
(10) applying with a handgun (turf) sprayer;
(11) mixing/loading/applying liquid with a low pressure handwand;
(12) mixing/ loading/applying with a backpack sprayer;
(13) mixing/ loading/applying with a hose end sprayer;
(14) mixing/loading/applying with a paintbrush; and
(15) flagging for aerial spray application.

2.1.2 Handler Exposure Scenarios -- Data and Assumptions

No chemical-specific handler exposure data were submitted in support of the reregistration of malathion. Therefore, an exposure assessment for each scenario was developed, where appropriate data are available, using the Pesticide Handlers Exposure Database (PHED) Version 1.1.[7] PHED was designed by a task force consisting of representatives from the U.S. EPA, Health Canada, the California Department of Pesticide Regulation, and member companies of the American Crop Protection Association. PHED is a generic database containing measured exposure data for workers involved in the handling or application of pesticides in the field (i.e., currently contains data for over 2,000 monitored exposure events). The basic assumption underlying the system is that exposure to pesticide handlers can be calculated using the monitored data as exposure is primarily a function of the physical

parameters of the handling and application process (e.g., packaging type, application method, and clothing scenario). PHED also contains algorithms that allow the user to complete surrogate task-based exposure assessments beginning with one of the four main data files contained in the system (i.e., mixer/loader, applicator, flagger, and mixer/loader/applicator).

Users can select data from each major PHED file and construct exposure scenarios that are representative of the use of the chemical. However, to add consistency to the risk assessment process, the EPA in conjunction with the PHED task force has evaluated all data within the system and developed surrogate exposure tables that contain a series of standard unit exposure values for various exposure scenarios. These standard unit exposure values are based on the "best fit" values calculated by PHED. PHED calculates "best fit" exposure values by assessing the distributions of exposures for each body part included in datasets selected for the assessment (e.g., chest or forearm) and then calculating a composite exposure value representing the entire body. PHED categorizes distributions as normal, lognormal, or in any "other" category. Generally, most data contained in PHED are lognormally distributed or fall into the PHED "other" distribution category. If the distribution is lognormal, the geometric mean for the distribution is used in the "best fit" exposure value. If the data are an "other" distribution, the median value of the dataset is used in the calculation of the "best fit" exposure value. As a result, the surrogate unit exposure values that serve as the basis for this assessment generally range from the geometric mean to the median of the selected dataset.[7]

Table 3 summarizes the caveats and parameters specific to the surrogate data used for each scenario and corresponding exposure/risk assessment. These caveats include the source of the data and an assessment of the overall quality of the data. The assessment of data quality is based on the number of observations and the available quality control data. The quality control data are based on a grading criteria established by the PHED task force.

The following assumptions and factors were used to complete this exposure assessment:

- Average body weight of an adult handler is 70 kg. This body weight is used in both the short- and intermediate-term assessment, since the endpoint of concern is not sex-specific (i.e., the cholinesterase inhibition could be assumed to occur in males or females).

- Average work day interval represents an 8 hour workday (e.g., the acres treated or volume of spray solution prepared in a typical day).

- Daily acres and volumes (as appropriate) to be treated in each scenario include:

  -- 350 acres for aerial and chemigation applications (including flaggers supporting aerial applications);
  -- 1,500 acres for mosquito aerial applications (non-ULV, e.g., EPA Reg. Nos. 10827-38 & 5905-196);
  -- 1200 acres for ULV aerial applications to agricultural crops;
  -- 7,500 acres for ULV aerial applications to mosquitoes;
  -- 80 acres for groundboom applications to agricultural crops and berries;
  -- 10 acres for groundboom applications to ornamentals;
  -- 40 acres for airblast applications on agricultural crops pine trees and ornamentals;
  -- 160 gallons for fogger applications on mosquitoes using a thermal fogger;

-- 16 gallons for ULV fogger applications on mosquitoes using a non-thermal fogger;
-- 6,000 square feet for power duster to grain stored in storage silos;
-- 40 gallons for a low pressure handwand to treat stored grain facilities and agricultural premises;
-- 1000 square feet for low pressure handwand spot treatment of turf;
-- 40 gallons for a low pressure handwand to ornamentals;
-- 5 acres for handgun turf;
-- 9,000 square feet for a hose end sprayer to mushroom houses;
-- 5 gallons for a paintbrush to windows screens and wineries for pest control.

- For fogging mosquitoes with a fogger, no PHED data were available; thus, as a surrogate, the PHED baseline unit exposure data for an airblast sprayer (0.36 mg/lb ai for dermal and 4.5 µg/lb for inhalation) were used to calculate dermal and inhalation exposure. In addition, the gallons handled were taken from information provided on the label (EPA Reg. 4787-8) which indicated that a thermal fogger sprays at a rate of 40 gal/hr and a non-thermal fogger sprays at a rate of 4 gal/hr. EPA assumed the fogger was used 4 hrs per day.

- For loading dusts for a power duster, no PHED data were available; thus, as a surrogate, the PHED baseline unit exposure data for wettable powders (3.7 mg/lb ai for dermal and 43 µg/lb for inhalation) were used to calculate dermal and inhalation exposure.

- Calculations are completed for a range of maximum application rates from residue field trials in support of food tolerance for agricultural uses based on the RED team memo.[1,3] For non-agricultural uses maximum application rates were identified for crop groupings, as listed on the available malathion labels and LUIS reports.[5,6] This results in an exposure/risk assessment that brackets risk levels associated with the various use patterns.

- When scenario-specific data are not available, HED calculates unit exposure values using generic protection factors that are applied to represent the use of personal protective equipment (PPE) and engineering controls.

2.1.3 Handler Exposure Risk Estimates

Handler exposure assessments are completed by EPA using a baseline exposure scenario and, if required, increasing levels of risk mitigation (PPE and engineering controls) to achieve a target margin of exposure. The baseline scenario generally represents a handler wearing long pants, a long-sleeved shirt, no respirator, and no chemical-resistant gloves. The calculation of baseline exposures are presented in Table 4. These daily exposures are used to complete the baseline dermal and inhalation risk assessment for the short and intermediate-term exposure scenarios (Table 5). Table 6 includes exposure/risk calculations for increasing levels of PPE. Table 7 includes exposure/risk calculations for engineering controls.

The calculations of daily dermal and inhalation exposure to malathion by handlers were used to calculate the daily dose, and hence the risks, to those handlers. Potential daily dermal exposure was calculated using the following formula:

$$Daily\ Dermal\ Exposure\left(\frac{mg\ ai}{day}\right) = Unit\ Exposure\left(\frac{mg\ ai}{lb\ ai}\right) x\ Use\ Rate\left(\frac{lb\ ai}{A}\right) x\ Daily\ Acres\ Treated\left(\frac{A}{day}\right)$$

A dermal absorption value was not needed for short- and intermediate-term dermal exposure because the dermal NOAEL was based on a 21-day dermal study; however, for long-term (chronic) dermal exposure, a 2-year feeding study was used and a 10% dermal absorption correction factor was applied.

Potential daily inhalation exposure was calculated using the following formula:

$$Daily\ Inhalation\ Exposure\left(\frac{mg\ ai}{day}\right) =$$
$$Unit\ Exposure\left(\frac{\mu g\ ai}{lb\ ai}\right) x\ Conversion\ Factor\left(\frac{1mg}{1{,}000\ \mu g}\right) x\ Use\ Rate\left(\frac{lb\ ai}{A}\right) x\ Daily\ Acres\ Treated\left(\frac{A}{day}\right)$$

A 100 percent inhalation absorption value was assumed.

The daily dermal and inhalation dose was calculated using a 70 kg body weight for both short-term and intermediate-term exposure as follows:

$$Daily\ Dermal\ Dose\left(\frac{mg\ ai}{Kg/Day}\right) = Daily\ Dermal\ Exposure\left(\frac{mg\ ai}{Day}\right) x\left(\frac{1}{Body\ Weight\ (Kg)}\right)$$

$$Daily\ Inhalation\ Dose\left(\frac{mg\ ai}{kg/day}\right) = Daily\ Inhalation\ Exposure\left(\frac{mg\ ai}{day}\right) x\left(\frac{1}{Body\ Weight\ (kg)}\right)$$

The calculations of both the daily dermal dose and the daily inhalation dose of malathion received by handlers were used to calculate the short-term and intermediate-term dermal and inhalation MOEs. The dermal MOE was calculated using a NOAEL of 50 mg/kg/day, and the inhalation MOE was calculated using a NOAEL of 25.8 mg/kg/day. The following formula describes the calculation of a dermal MOE:

$$Dermal\ MOE = \frac{NOEL\left(\frac{mg}{kg/day}\right)}{Dermal\ Daily\ Dose\left(\frac{mg}{kg/day}\right)}$$

The following formula describes the calculation of an inhalation MOE:

$$Inhalation\ MOE = \frac{NOEL\left(\frac{mg}{kg/day}\right)}{Inhalation\ Daily\ Dose\left(\frac{mg}{kg/day}\right)}$$

The target dermal MOE, including short-, intermediate and long-term exposure periods, is 100 for cholinesterase inhibition. The target inhalation MOE, including short-, intermediate and long-term exposure periods, is 1000 for histopathology in respiratory epithelium. Chronic exposure is not expected for handlers, and therefore is not assessed. The short- and intermediate-term dermal toxicity endpoint (i.e., cholinesterase inhibition) is also seen from inhalation exposure (NOAEL of 25.8 mg/kg/day). Contribution of inhalation exposure to cholinesterase inhibition is relatively insignificant compared to dermal exposure. However, because the effect of concern is the same, the exposure contributed from both dermal and inhalation routes are added together to give an indication of the combined risk for cholinesterase inhibition. Both routes have the same target MOE for cholinesterase inhibition (i.e., 100), however, since the NOAELs are different for dermal (50 mg/kg/day) and inhalation (25.8 mg/kg/day), the total risk (i.e., total MOE) for this effect is estimated by combining MOEs from each route.

In order to calculate a Total MOE, the reciprocals of the dermal and inhalation MOEs are combined and divided into 1. The above operations are represented as follows:

$$\text{Total MOE} = \frac{1}{\frac{1}{MOE_{dermal}} + \frac{1}{MOE_{inhalation}}}$$

A total MOE $\geq$ 100 (for cholinesterase inhibition) does not present a concern for handler exposure. Likewise, an inhalation MOE $\geq$ 1000 (for histopathology in respiratory epithelium) does not present a concern for handler exposure.

Table 3: Occupational Exposure Scenario Descriptions for the Use of Malathion

Exposure Scenario (Number)	Data Source	Standard Assumptions[a] (8-hr work day)	Comments[b]
Mixer/Loader Descriptors			
Mixing/Loading Liquid Formulations (1a/1b/1c/1d/1e/1f)	PHED V1.1 (Revised Version 8/98)	80 acres (ag) and 40 acres (golf course turf), 80 acres (sod farm) and 10 acres (ornamentals) for groundboom; 350 acres (ag, turf and pine trees), 1,500 acres (mosquitoes), 1200 acres (ULV ag crops), 7,500 acre (ULV mosquitoes) for aerial ; 40 acres (ag and ornamentals), for airblast sprayer, 100 gallons for grape root dip, 160 gallons for thermal fogger & 16 gallons for non-thermal fogger, and 5 acres for handgun (turf)	**Baseline:** Hands, dermal, and inhalation = AB grades. Hands = 53 replicates; Dermal = 72 to 122 replicates; and Inhalation = 85 replicates. High confidence in hands/ dermal, and inhalation data. No protection factor was needed to define the unit exposure value. **PPE.:** The same dermal data are used as for baseline with gloves on hands. A 5-fold PF (e.g. 80% PF) was applied to the baseline inhalation data. The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing for all scenarios, except groundboom and fogger where a SINGLE layer of clothing only was needed. Hands = AB grades. Hands = 59 replicates. High confidence in hands data. **Engineering Controls:** Hands, dermal, and inhalation = AB grades. Hands = 31 replicates; Dermal= 16 to 22; and Inhalation = 27 replicates. High confidence in hands/ dermal, and inhalation data. No protection factor was needed to define the unit exposure value.
Mixing/Loading Dust Formulations (2)	PHED V1.1 (Revised Version 8/98)	6,000 sq ft was assumed for grain (assumes maximum treatment of ten 60,000 bushel bins, each with a surface area of 600 sq ft)	**Baseline:** Hands, dermal, and inhalation = ABC grades. Hands = 7 replicates; Dermal = 22 to 45 replicates; and Inhalation = 44 replicates. Low confidence in hands/ dermal, and medium confidence in inhalation data. No protection factor was needed to define the unit exposure value. **PPE.:** This assessment is not required. **Engineering Controls:** This assessment is not required.
Mixing/Loading Wettable Powder Formulations (3a/3b/3c)	PHED V1.1 (Revised Version 8/98)	80 acres for groundboom applications; 350 acres for aerial applications; and 40 acres for airblast applications	**Baseline:** Hands, dermal, and inhalation = ABC grades. Hands = 7 replicates; Dermal = 22 to 45 replicates; and Inhalation = 44 replicates. Low confidence in hands/ dermal, and medium confidence in inhalation data. No protection factor was needed to define the unit exposure value. **PPE.:** The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. A 5-fold PF (e.g. 80% PF) was applied to the baseline inhalation data. Hands = ABC grades. Hands = 24 replicates. Medium confidence in hands data. **Engineering Controls**: Hands = AB grades; dermal and inhalation = all grade. Hands = 5 replicates; Dermal = 6 to 15 replicates; and Inhalation = 15 replicates. Low confidence in the hands, dermal and inhalation data. No protection factor was needed to define the unit exposure value. Engineering controls are based on water soluble packets.
Applicator Descriptors			

Table 3: Occupational Exposure Scenario Descriptions for the Use of Malathion (Continued)

Exposure Scenario (Number)	Data Source	Standard Assumptions[a] (8-hr work day)	Comments[b]
Applying Sprays with an Airblast Sprayer (4)	PHED V1.1 (Revised Version 8/98)	40 acres (ag, berries, and ornamentals)	**Baseline:** Hands, dermal , and inhalation = AB grades. Hands = 22 replicates, dermal = 32 to 49 replicates, and inhalation = 47 replicates. High confidence in hands, dermal, and inhalation data. No protection factor was needed to define the unit exposure value. **PPE.:** The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. A 5-fold PF (e.g. 80% PF) was applied to the baseline inhalation data. Hands = AB grades. Hands = 18 replicates. High confidence in hands data. **Engineering Controls:** Hands and dermal = AB grade, and inhalation = ABC grade. Back calculated from glove data assuming gloves provide 90% protection. Dermal = 27 to 30 replicates; and inhalation = 9 replicates. Low confidence in dermal data; and low confidence in inhalation data (based on low replicates).
Applying Sprays with a Groundboom Sprayer (5)	PHED V1.1 (Revised Version 8/98)	80 acres (ag, sod farm and berries), 10 acres (ornamentals) and 40 acres for golf course turf	**Baseline**: Hands, dermal, and inhalation = AB grades. Hands =29 replicates, dermal = 23 to 42 replicates, and inhalation = 22 replicates. High confidence in hands, dermal, and inhalation data. No protection factor was needed to define the unit exposure value. **PPE.**: This assessment is not required. **Engineering Controls**: This assessment is not required.
Applying Sprays with a Fixed-wing Aircraft (6) [note: fixed-wing data are assumed to cover helicopter application, as well. Helicopter data in PHED are insufficient for a meaningful evaluation]	PHED V1.1 (Revised Version 8/98)	350 acres (ag, ornamentals and turf), 1,500 acres (mosquitoes), 1200 acres (ULV ag crops), and 7,500 acres (ULV mosquitoes)	**Engineering Controls:** Hands = AB grade, dermal and inhalation = ABC grade. Hands= 34 replicates, dermal = 24 to 48 replicates, and inhalation = 23 replicates. Medium confidence in hands, dermal, and inhalation data. No protection factor was needed to define the unit exposure value.
Applying Sprays with a Fogger (7)	PHED V1.1 (Revised Version 8/98)	160 gallons thermal fogger (mosquitoes) and 16 gallons non-thermal fogger (mosquitoes)	**Baseline**: Hands, dermal , and inhalation = AB grades. Hands = 22 replicates, dermal = 32 to 49 replicates, and inhalation = 47 replicates. High confidence in hands, dermal, and inhalation data. No protection factor was needed to define the unit exposure value. **PPE.**: The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. A 5-fold PF (e.g. 80% PF) was applied to the baseline inhalation data. Hands = AB grades. Hands = 18 replicates. High confidence in hands data. **Engineering Controls**: Hands and dermal = AB grade, and inhalation = ABC grade. Back calculated from glove data assuming gloves provide 90% protection. Dermal = 27 to 30 replicates; and inhalation = 9 replicates. Low confidence in dermal data; and low confidence in inhalation data (based on low replicates).

Table 3: Occupational Exposure Scenario Descriptions for the Use of Malathion (Continued)

Exposure Scenario (Number)	Data Source	Standard Assumptions[a] (8-hr work day)	Comments[b]
Applying Dusts with a Power Duster (8)	No Data	6,000 sq ft	No Data
Dipping Plants (9)	No Data	No Data	No Data
Applying with a Handgun (turf) Sprayer (10)	PHED V1.1 (Revised Version 8/98)	5 acres	**Baseline:** Dermal = C grade (0 to 14 replicates). No Head and Neck data. Hands = C grade (14 replicates). Data for gloved hands only. Inhalation = B grade (14 replicates). Low confidence in dermal, hands and inhalation data. **PPE:** The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. A 5-fold PF (e.g. 80% PF) was applied to the baseline inhalation data. **Engineering Controls**: Not feasible.
Mixer/Loader/Applicator Descriptors			
Mixing/Loading/Applying with a Low Pressure Handwand (11)	PHED V1.1 (Revised Version 8/98)	40 gal (grain and agricultural premises), 40 gallons (ornamentals), 40 gallons for commercial and 1000 square feet for homeowner (spot treat turf)	**Baseline**: Dermal and inhalation = ABC grades; hands= all grades. Dermal = 9 to 80 replicates, inhalation = 80 replicates, and hands = 70 replicates. Low confidence in hands and dermal; and medium confidence in inhalation data. No protection factor was needed to define the unit exposure value. **PPE.**: The same dermal data are used as for baseline. A 5-fold PF (e.g. 80% PF) was applied to the baseline inhalation data. Hands = ABC grades. Hands = 10 replicates. Low confidence in hands data. **Engineering Controls**: Not feasible.

Table 3: Occupational Exposure Scenario Descriptions for the Use of Malathion (Continued)

Exposure Scenario (Number)	Data Source	Standard Assumptions[a] (8-hr work day)	Comments[b]
Mixing/Loading/Applying with a Backpack Sprayer (12)	PHED V1.1 (Revised Version 8/98)	40 gal (grain and agricultural premises) and 40 gallons (ornamentals), 40 gallons for commercial and 1000 square feet for homeowner (spot treat turf)	**Baseline**: No data for dermal and hands. Inhalation= A grade. Inhalation= 11 replicates. Low confidence in inhalation data. **PPE.**: Dermal= AB grade each, hands= C grade. Dermal= 9 to 11 replicates, and hands = 11 replicates. Low confidence in dermal and hands data. A 5-fold PF (e.g., 80% PF) was applied to the baseline inhalation data. A 50% PF was applied to dermal. **Engineering Controls**: Not feasible.
Mixing/Loading/Applying with a Hose End Sprayer (13)	PHED V1.1 (Revised Version 8/98)	9,000 sq ft (mushrooms)	**Baseline:** Hands = E grade, dermal = C grades, and inhalation = ABC grades. Hands = 8 replicates; Dermal = 8 replicates; and Inhalation = 8 replicates. Low confidence in hands/ dermal, and inhalation data. No protection factor was needed to define the unit exposure value. **PPE.:** No Data **Engineering Controls:** Not required for assessment.
Mixing/Loading/Applying with a Paintbrush (14)	PHEDV1.1 (Revised Version 8/98)	5 gallons (mosquitoes)	**Baseline:** Dermal and inhalation = C grade; hands = AB grade. Dermal = 14 to 15 replicates, hands= 15 replicates and inhalation = 15 replicates. Low confidence in dermal, and hands data. Medium confidence in inhalation data. **PPE.:** No Data. PPE calculated for gloves by adding 90% protection factor to baseline hand exposure. **Engineering Controls:** No Data
Flagger Descriptors			

Table 3: Occupational Exposure Scenario Descriptions for the Use of Malathion (Continued)

Exposure Scenario (Number)	Data Source	Standard Assumptions[a] (8-hr work day)	Comments[b]
Flagging Aerial Spray Applications (15)	PHED V1.1 (Revised Version 8/98)	350 acres (ag, berries, ornamentals and turf), 1,500 acres (mosquitoes), 1200 acres (ULV ag crops), and 7,500 acres (ULV mosquitoes). Note that human flagging for greater than 350 acres is unlikely, due to the usual employment of GPS systems for large acreages and sites. However, current labels do not preclude human flaggers for large acreage applications.	**Baseline:** Hands, dermal, and inhalation = AB grades. Dermal = 18 to 28 replicates; Hands = 30 replicates; and Inhalation = 28 replicates. High confidence in dermal, hands, and inhalation data. **PPE.**: The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. Hands = AB grades. Hands= 6 replicates. Low confidence in hands data. **Engineering Controls**: Enclosed groundboom data are used as a surrogate for engineering controls for flaggers. Dermal and hands = ABC grades; Inhalation = AB grades. Dermal = 20 to 31 replicates; Hands = 16 replicates; and Inhalation = 16 replicates. Medium confidence in dermal and hands data. High confidence in inhalation data.

a Standard Assumptions based on an 8-hour work day as estimated by HED. BEAD data were not available.

b "Best Available" grades are defined by HED SOP for meeting Subdivision U Guidelines. Best available grades are assigned as follows: matrices with grades A and B data and a minimum of 15 replicates; if not available, then grades A, B and C data and a minimum of 15 replicates; if not available, then all data regardless of the quality and number of replicates. Data confidence are assigned as follows:

High = grades A and B and 15 or more replicates per body part
Medium = grades A, B, and C and 15 or more replicates per body part
Low = grades A, B, C, D and E or any combination of grades with less than 15 replicates

Table 4: Occupational Handler Short- and Intermediate-term Dermal and Inhalation Exposures to Malathion at Baseline

Exposure Scenario (Scen. #)	Baseline Dermal Unit Exposure[a] (mg/lb ai)	Baseline Inhalation Unit Exposure[b] (μg/lb ai)	Range of Application Rates[c] (lb ai/acre)	Crop Type or Target[d]	Amount Handled per Day[e]	Daily Dermal Exposure[f] (mg/day)	Daily Inhalation Exposure[g] (mg/day)
Mixer/Loader Exposure							
Mixing/Loading Liquids for Groundboom Application (1a)	2.9	1.2	1.25	ag low [1]	80 acres	290	0.12
			2.0	ag medium[2]		464	0.19
			5.0	ag high[3]		1160	0.48
			8.7	golf course turf[4]	40 acres	1009	0.42
			8.7	sod farms[4]	80 acres	2018	0.84
			2.5	ornamentals[5]	10 acres	72.5	0.03
Mixing/Loading Liquids for Aerial and Chemigation Application (1b)	2.9	1.2	1.25	ag low [1]	350 acres	1269	0.53
			2.0	ag medium[2]		2030	0.84
			5	ag high[3]		5075	2.1
			6.25	citrus [6]		6344	2.6
			2.5	pine trees[5]		2538	1.1
			8.7	turf[4]		8831	3.7
			1.22	ULV ag crops [7]	1200 acres	4245	1.8
			0.5	mosquitoes[8]	1,500 acres	2175	0.90
			0.23	ULV mosquitoes[9]	7,500 acres	5,003	2.1
Mixing/Loading Liquids for Airblast Sprayer (1c)	2.9	1.2	6.25	citrus [6]	40 acres	725	0.30
			3.75	stone fruits[10]		435	0.18
			2.5	ornamentals[5]		290	0.12
			1.25	pome fruits [11]		145	0.06
Mixing/Loading Liquids for Dipping (1d)	2.9	1.2	1.9 lb ai/100 gal.	grape root dip[12]	100 gal	5.5	0.0023

Table 4: Occupational Handler Dermal and Inhalation Exposures to Malathion at Baseline (continued)

Exposure Scenario (Scen. #)	Baseline Dermal Unit Exposure[a] (mg/lb ai)	Baseline Inhalation Unit Exposure[b] (μg/lb ai)	Range of Application Rates[c] (lb ai/acre)	Crop Type or Target[d]	Amount Handled per Day[e]	Daily Dermal Exposure[f] (mg/day)	Daily Inhalation Exposure[g] (mg/day)
Mixing/Loading Liquids for a Fogger (truck) (1e)	2.9	1.2	0.51 lb ai/gal	thermal fogger[9] (mosquitoes)	160 gal	237	0.098
			9.9 lb ai/gal	non-thermal fogger[9] (mosquitoes)	16 gal	460	0.19
Mixing/Loading Liquids for Handgun (1f)	2.9	1.2	8.7	turf[4]	5 acres	126	0.052
Loading Dusts for Power Duster of Direct Application (2)	3.7[h]	43[h]	0.3 lbs ai/1,000 sq. ft.	stored grain[13]	6,000 sq. ft.	6.7	0.077
Mixing/Loading Wettable Powders for Groundboom Application (3a)	3.7	43	2	berries[14]	80 acres	592	6.9
Mixing/Loading Wettable Powders for Aerial Application (3b)	3.7	43	2	berries[14]	350 acres	2590	30
Mixing/Loading Wettable Powders for Airblast Sprayer (3c)	3.7	43	2	berries[14]	40 acres	295	3.45
Applicator Exposure							
Applying Sprays with an Airblast Sprayer (4)	0.36	4.5	6.25	citrus [6]	40 acres	90	1.1
			3.75	stone fruits[10]		54	0.67
			2.5	ornamentals[5]		36	0.45
			1.25	pome fruits [11]		18	0.22
Applying Sprays with a Groundboom Sprayer (5)	0.014	0.74	1.25	ag low [1]	80 acres	1.4	0.07
			2.0	ag medium[2]		2.2	0.12
			5.0	ag high[3]		5.6	0.30
			8.7	golf course turf[4]	40 acres	4.9	0.26
			8.7	sod farm[4]	80 acres	9.7	0.52
			2.6	ornamentals[5]	10 acres	0.35	0.019

Table 4: Occupational Handler Dermal and Inhalation Exposures to Malathion at Baseline (continued)

Exposure Scenario (Scen. #)	Baseline Dermal Unit Exposure[a] (mg/lb ai)	Baseline Inhalation Unit Exposure[b] (μg/lb ai)	Range of Application Rates[c] (lb ai/acre)	Crop Type or Target[d]	Amount Handled per Day[e]	Daily Dermal Exposure[f] (mg/day)	Daily Inhalation Exposure[g] (mg/day)
Applying Sprays with a Fixed-Wing Aircraft (6)	See Engineering Controls	See Engineering Controls	1.25	ag low [1]	350 acres	See Engineering Controls	See Engineering Controls
			2.0	ag medium[2]			
			5.0	ag high[3]			
			6.25	citrus [6]			
			2.5	pine trees[5]			
			8.7	turf[4]			
			1.22	ULV ag crops[7]	1200 acres		
			0.5	mosquitoes[8]	1,500 acres		
			0.23	ULV mosquitoes[9]	7,500 acres		

Table 4: Occupational Handler Dermal and Inhalation Exposures to Malathion at Baseline (continued)

Exposure Scenario (Scen. #)	Baseline Dermal Unit Exposure[a] (mg/lb ai)	Baseline Inhalation Unit Exposure[b] (μg/lb ai)	Range of Application Rates[c] (lb ai/acre)	Crop Type or Target[d]	Amount Handled per Day[e]	Daily Dermal Exposure[f] (mg/day)	Daily Inhalation Exposure[g] (mg/day)
Applying Sprays with a Fogger (7)	0.36[i]	4.5[i]	0.51 lb ai/gal	thermal fogger[9] (mosquitoes)	160 gal	29	0.38
			9.9 lb ai/gal	non-thermal fogger[9] (mosquitoes)	16 gal	57	0.71
Applying Dusts with a Power Duster (8)	No Data	No Data	0.3 lb ai/1,000 sq. ft.	stored grains[13]	6,000 sq. ft.	No Data	No Data
Dipping Plants (9)	No Data	No Data	1.9 lb ai/100 gal	grape root dip[12]	100 gal	No Data	No Data
Applying with Handgun (turf) Sprayer (10)	0.34[j]	1.4	8.7	turf[4]	5 acres	15	0.06
Mixer/Loader/Applicator Exposure							
Mixing/Loading/Applying Liquid with a Low Pressure Handwand (11)	100	30	5 lb ai/20 gallons	stored grain facility[13]	40 gal	1,000	0.3
			0.27 lb/gal	agricultural premises[15]		1,080	0.32
			0.026 lb/gal	ornamentals[5]		104	0.38
			0.049 lb/gal	turf[4]		196	0.26
Mixing/Loading/Applying liquids with a Backpack Sprayer (12)	See PPE.	See PPE.	5 lb ai/20 gallons	stored grain facility[13]	40 gal	See PPE.	See PPE.
			0.27 lb ai/gal	agricultural premises[15]			
			0.026 lb ai/gal	ornamentals[5]			
			0.049 lb ai/gal	turf[4]			
Mixing/Loading/Applying with a Hose End Sprayer (13)	31	9.5	0.039 lb ai/1,000 sq. ft.	mushrooms[16]	9,000 sq. ft.	11	0.0033
Mixing/Loading/Applying with a Paintbrush (14)	180	280	0.1 lb ai/gal	mosquitoes[8]	5 gal	90	0.14

Table 4: Occupational Handler Dermal and Inhalation Exposures to Malathion at Baseline (continued)

Exposure Scenario (Scen. #)	Baseline Dermal Unit Exposure[a] (mg/lb ai)	Baseline Inhalation Unit Exposure[b] (μg/lb ai)	Range of Application Rates[c] (lb ai/acre)	Crop Type or Target[d]	Amount Handled per Day[e]	Daily Dermal Exposure[f] (mg/day)	Daily Inhalation Exposure[g] (mg/day)
Flagger Exposure							
Flagging for Aerial Spray Applications (15)	0.011	0.35	1.25	Ag low [1]	350 acres	4.8	0.15
			2.0	Ag medium[2]		7.7	0.25
			5.0	Ag high[3]		19	0.61
			6.25	citrus [6]		24	0.76
			2.5	pine trees[5]		9.6	0.31
			8.7	turf[4]		34	1.1
			1.22	ULV ag crops[7]	1200 acres	16	0.51
			0.5	mosquitoes[8]	1,500 acres	8.3	0.26
			0.23	ULV mosquitoes[9]	7,500 acres	19	0.60

Table 4: Occupational Handler Dermal and Inhalation Exposures to Malathion at Baseline (continued)

Footnotes:

a Baseline dermal unit exposure represents long pants, long sleeved shirt, no gloves, and open mixing/loading. PHED Surrogate Exposure Guide - Draft. August 1998.
b Baseline inhalation unit exposure represents no respirator. PHED Surrogate Exposure Guide - Draft. August 1998.
c Application rates are based on maximum application rates from residue field trials in support of food tolerances.
d Crop types or targets are selected as follows:
- 1 Based on maximum application rates from residue field trials in support of food tolerances for brassica vegetables.
- 2 Based on maximum application rates from residue field trials in support of food tolerances for leafy vegetables and berries.
- 3 Based on maximum application rates from residue field trials in support of food tolerance for pineapples.
- 4 Based on labeled maximum rates for turf, including golf course turf, sod farms and lawns of residences, businesses and parks. (EPA Reg. 655-777, 769-621 and 909-101)
- 5 Based on labeled maximum rates for ornamentals and pine trees (EPA Reg. 655-777 and 67760-1).
- 6 Based on maximum application rates from residue field trials in support of food tolerances for citrus fruit.
- 7 Based on labeled maximum rates for ULV-type agricultural crops (e.g., corn, wheat, and grain). (EPA Reg. 4787-8)
- 8 Based on labeled maximum rates for mosquitoes including standing water (based on residue field trials) and terrestrial uses (EPA Reg. 34704-108).
- 9 Based on labeled maximum rates for mosquitoes applications for ULV-type (EPA Reg. 4787-8).
- 10 Based on maximum application rates from residue field trials in support of food tolerances for stone fruits.
- 11 Based on maximum application rates from residue field trials in support of food tolerances for pome fruits.
- 12 Based on maximum application rates for grape root dip.
- 13 Based on maximum application rates for stored grain (surface treatments to corn, wheat, barley, oats, rye with dust formulations and treatment of grain storage facilities with EC formulations.
- 14 Based on maximum application rates from residue field trials in support of food tolerances for berries.
- 15 Based on maximum application rates for poultry premises and agricultural premises used as a bait spray.
- 16 Based on maximum application rates from residue field trials in support of food tolerances for mushrooms.

e Amount handled per day are from EPA estimates of acres treated, gallons applied, or square feet treated.
f Daily Dermal Exposure (mg/day) = Dermal Unit Exposure (mg/lb ai) x Application Rates (lb ai/acre; lb/gal; and ai/sq ft) x Amount Handled per day (acres, gallons, sq. ft.).
g Daily Inhalation Exposure (mg/day) = Inhalation Unit Exposure (μg/lb ai) x (1 mg/1,000 μg) Conversion x Application rate (lb ai/acre; lb/gal; and ai/sq ft) x Amount Handled per day (acres, gallons, sq. ft.)
h Mixing/loading wettable powders is applied as a “surrogate” to mixing/loading dusts.
i Applying sprays with a fogger uses “surrogate” PHED data for applying sprays with an airblast sprayer.
j Because the dermal unit exposure in PHED includes protection from use of gloves, dermal risk is assessed in Table 6, and not under "Baseline" scenarios in Table 5.
NF Not Feasible.

Table 5: Occupational Handler Short-term and Intermediate-term Risks from Malathion at Baseline.

Exposure Scenario (Scenario #)	Crop Type or Target	Baseline Dermal		Baseline Inhalation		Baseline Total
		Daily Dose (mg/kg/day)[a]	MOE[b]	Daily Dose (mg/kg/day)[c]	MOE[d]	Total MOE
Mixer/Loader Exposure						
Mixing/Loading Liquids for Groundboom Application (1a)	ag low	4.1	12	0.002	15,000	12
	ag medium	6.6	8	0.0027	9,400	8
	ag high	17	3	0.0069	3800	3
	golf course turf	14	4	0.0060	4,300	4
	sod farm	29	2	0.012	2,200	2
	ornamentals	1.0	50	0.00043	60,000	50
Mixing/Loading Liquids for Aerial and Chemigation Application (1b)	ag low	18	3	0.0075	3400	3
	ag medium	29	2	0.012	2200	2
	ag high	73	0.7	0.03	860	0.7
	citrus	91	0.6	0.038	690	0.6
	pine trees	36	1.4	0.015	1,700	1.4
	turf	130	0.4	0.052	490	0.40
	ULV ag crops	61	0.82	0.025	1,000	0.8
	mosquitoes	31	1.6	0.013	2,000	1.6
	ULV mosquitoes	72	0.70	0.03	870	0.7
Mixing/Loading Liquids for Airblast Sprayer (1c)	citrus	10	5	0.0043	6000	5
	stone fruits	6.2	8	0.0026	10,000	8
	ornamentals	4.1	12	0.0017	15,000	12
	pome fruits	2.1	24	0.00086	30,000	24
Mixing/Loading Liquids for Dipping (1d)	grape root dip	0.079	640	0.000033	790,000	640

Table 5: Occupational Handler Short-term and Intermediate-term Risks from Malathion at Baseline (continued)

Exposure Scenario (Scenario #)	Crop Type or Target	Baseline Dermal		Baseline Inhalation		Baseline Total
		Daily Dose (mg/kg/day)[a]	MOE[b]	Daily Dose (mg/kg/day)[c]	MOE[d]	Total MOE
Mixing/Loading Liquids for a Fogger (1e)	thermal fogger (mosquitoes)	3.4	15	0.0014	18,000	15
	non-thermal fogger (mosquitoes)	6.6	7.6	0.0027	9,500	8
Mixing/Loading Liquids for Handgun (1f)	turf	1.8	28	0.00075	35,000	28
Mixing/Loading Dusts for Power Duster or Direct Application (2)	stored grain facility	0.095	530	0.0011	23,000	520
Mixing/Loading Wettable Powders for Groundboom Application (3a)	berries	8.5	6	0.098	260	6
Mixing/Loading Wettable Powders for Aerial Application (3b)	berries	37	1.4	0.43	60	1.3
Mixing/Loading Wettable Powders for Airblast Sprayer (3c)	berries	4.2	12	0.049	525	12
Applicator Exposure						
Applying Sprays with an Airblast Sprayer (4)	citrus	1.3	39	0.016	1600	38
	stone fruits	0.77	65	0.0096	2700	63
	ornamentals	0.51	97	0.0064	4000	95
	pome fruits	0.26	190	0.0032	8000	190
Applying Sprays with a Groundboom Sprayer (5)	ag low	0.02	2500	0.0011	24,000	2,300
	ag medium	0.032	1600	0.0017	15,000	1,400
	ag high	0.08	630	0.0042	6100	570
	golf course turf	0.070	720	0.0037	7,000	650
	sod farm	0.14	360	0.0074	3,500	330
	ornamentals	0.005	10,000	0.00026	98,000	9,100
Applying Sprays with a Fixed-Wing Aircraft (liquid formulations) (6)	ag low, ag medium, ag high, citrus, pine trees, turf, ULV ag crops, mosquitoes, ULV mosquitoes	See Eng. Controls	See Eng. Controls	See Eng. Controls	See Eng. Controls	See Eng. Controls
Applying Sprays with a Fogger (7)	thermal fogger (mosquitoes)	0.42	120	0.0052	4,900	120

Table 5: Occupational Handler Short-term and Intermediate-term Risks from Malathion at Baseline (continued)

Exposure Scenario (Scenario #)	Crop Type or Target	Baseline Dermal		Baseline Inhalation		Baseline Total
		Daily Dose (mg/kg/day)[a]	MOE[b]	Daily Dose (mg/kg/day)[c]	MOE[d]	Total MOE
	non-thermal fogger (mosquitoes)	0.81	61	0.010	2,500	60
Applying Dusts with a Power Duster (8)	stored grain facility	No Data	No Data	No Data	No Data	No Data
Dipping Plants (9)	grape root dip	No Data	No Data	No Data	No Data	No Data
Applying with a Handgun (turf) Sprayer (10)	turf	see PPE.	see PPE	see PPE	see PPE	see PPE
Mixer/Loader Applicator Exposure						
Mixing/Loading/Applying with a Low Pressure Handwand (11)	stored grain facility	14	3.5	0.0043	6,000	3.5
	agricultural premises	15	3.2	0.0046	5,600	3.2
	ornamentals	1.5	34	0.00045	58,000	34
	turf	2.8	18	0.00084	31,000	18
Mixing/Loading/Applying with a Backpack Sprayer (12)	stored grain facility	See PPE.	See PPE.	See PPE.	See PPE.	See PPE.
	agricultural premises					
	ornamentals					
	turf					
Mixing/Loading/Applying with a Hose End Sprayer (13)	mushrooms	0.16	320	4.8E-05	5.4E+05	320
Mixing/Loading/Applying with a Paintbrush(14)	mosquitoes	1.3	39	0.002	13,000	39
Flagger Exposure						
Flagging for Aerial Spray Applications (15)	ag low	0.07	730	0.0022	12,000	690

Table 5: Occupational Handler Short-term and Intermediate-term Risks from Malathion at Baseline (continued)

Exposure Scenario (Scenario #)	Crop Type or Target	Baseline Dermal		Baseline Inhalation		Baseline Total
		Daily Dose (mg/kg/day)[a]	MOE[b]	Daily Dose (mg/kg/day)[c]	MOE[d]	Total MOE
	ag medium	0.11	450	0.0035	7,400	420
	ag high	0.28	180	0.0088	2,900	170
	citrus	0.34	145	0.011	2,400	140
	pine trees	0.14	360	0.0044	5,900	340
	turf	0.48	100	0.015	1,700	94
	ULV ag crops	0.23	220	0.0073	3,500	200
	mosquitoes	0.12	420	0.0038	6,900	400
	ULV mosquitoes	0.27	185	0.009	3,000	170

[a] Daily Dermal Dose (mg/kg/day) = Daily Dermal Exposure (mg/day)/ Body weight (70 kg).
[b] Dermal MOE (short- and intermediate-term) = NOEL (50 mg/kg/day)/ Daily Dermal Dose (mg/kg/day).
[c] Daily Inhalation Dose (mg/kg/day) = Daily Inhalation Exposure (mg/day)/ Body weight (70 kg).
[d] Inhalation MOE (short- and intermediate-term) = NOEL (25.8 mg/kg/day)/ Daily Inhalation Dose (mg/kg/day).
[e] Total MOE (short- and Intermediate-term) = 1 / ((1/Calculated Dermal MOE) + (1 /Calculated Inhalation MOE)).
NF Not Feasible.

Table 6: Occupational Handler Short-term and Intermediate-term Risks from Malathion with Additional PPE.

Exposure Scenario (Scenario #)	Crop Type or Target	Dermal - Additional PPE.			Inhalation - Additional PPE.			Total - Additional PPE.
		Unit Exposure (mg/lb ai)[a]	Daily Dose (mg/kg/day)[b]	MOE[c]	Unit Exposure (µg/lb ai)[a]	Daily Dose (mg/kg/day)[d]	MOE[e]	Total MOE[f]
Mixer/Loader Exposure								
Mixing/Loading Liquids for Groundboom Application (1a)	ag low	0.023 (Gloves only)	0.033	1500	1.2 (No respirator)	0.002	15,000	1400
	ag medium		0.053	950		0.0027	9,400	860
	ag high		0.13	380		0.0069	3800	350
	golf course turf		0.11	440		0.006	4,300	400
	sod farms		0.23	220		0.012	2,200	200
	ornamentals		0.0082	6,100		0.00043	60,000	5,500
Mixing/Loading Liquids for Aerial and Chemigation Application (1b)	ag low	0.017	0.11	470	1.2 (No respirator)	0.0075	3400	410
	ag medium		0.17	290		0.012	2200	260
	ag high		0.43	120	0.24	0.006	4300	120
	citrus		0.53	94		0.0075	3400	92
	pine trees		0.21	240	1.2 (No respirator)	0.015	1700	210
	turf		0.74	68	0.24	0.010	2500	66
	ULV ag crops		0.36	140	1.2 (No respirator)	0.025	1000	120
	mosquitoes		0.18	270		0.013	2,000	240
	ULV mosquitoes		0.42	120	0.24	0.006	4400	120
Mixing/Loading Liquids for Airblast Sprayer (1c)	citrus	0.023 (Gloves only)	0.082	600	1.2 (No respirator)	0.0043	6000	550
	stone fruits		0.049	1000		0.0026	10,000	910
	ornamentals		0.033	1500		0.0017	15,000	1400
	pome fruits		0.016	3000		0.00086	30,000	2700
Mixing/Loading Liquids for Dipping (1d)	grape root dip	NA	NA	NA	NA	NA	NA	NA

Table 6: Occupational Handler Short-term and Intermediate-term Risks from Malathion with Additional PPE. (continued)

Exposure Scenario (Scenario #)	Crop Type or Target	Dermal - Additional PPE.			Inhalation - Additional PPE.			Total - Additional PPE.
		Unit Exposure (mg/lb ai)[a]	Daily Dose (mg/kg/day)[b]	MOE[c]	Unit Exposure (µg/lb ai)[a]	Daily Dose (mg/kg/day)[d]	MOE[e]	Total MOE[f]
Mixing/Loading Liquids for a Fogger (1e)	thermal fogger (mosquitoes)	0.023 (Gloves only)	0.027	1,900	1.2 (No respirator)	0.0014	18,000	1700
	non-thermal fogger (mosquitoes)		0.052	960		0.0027	9,500	870
Mixing/Loading Liquids for Handgun (1f)	turf	0.023 (Gloves only)	0.014	3,500	1.2 (No respirator)	0.00075	35,000	3200
Loading Dusts for Power Duster or Direct Application (2)	stored grain facility	NA	NA	NA	NA	NA	NA	NA
Mixing/Loading Wettable Powders for Groundboom Application (3a)	berries	0.13	0.30	170	8.6	0.020	1300	150
Mixing/Loading Wettable Powders for Aerial Application (3b)	berries		1.3	38		0.86	300	34
Mixing/Loading Wettable Powders for Airblast Sprayer (3c)	berries		0.15	340		0.0098	2600	300
Applicator Exposure								

Table 6: Occupational Handler Short-term and Intermediate-term Risks from Malathion with Additional PPE. (continued)

Exposure Scenario (Scenario #)	Crop Type or Target	Dermal - Additional PPE.			Inhalation - Additional PPE.			Total - Additional PPE.
		Unit Exposure (mg/lb ai)[a]	Daily Dose (mg/kg/day)[b]	MOE[c]	Unit Exposure (µg/lb ai)[a]	Daily Dose (mg/kg/day)[d]	MOE[e]	Total MOE[f]
Applying Sprays with an Airblast Sprayer (4)	citrus	0.22	0.79	64	0.9	0.0032	8000	63
	stone fruits		0.47	100	4.5 (No respirator)	0.0096	2700	100
	ornamentals		0.31	160		0.0064	4000	150
	pome fruits		0.26	190		0.0032	8000	190
Applying Sprays with a Groundboom Sprayer (5)	ag low	NA	NA	NA	NA	NA	NA	NA
	ag medium		NA	NA		NA	NA	NA
	ag high		NA	NA		NA	NA	NA
	golf course turf		NA	NA		NA	NA	NA
	sod farm		NA	NA		NA	NA	NA
	ornamentals		NA	NA		NA	NA	NA
Applying Sprays with a Fixed-Wing Aircraft (liquid formulations) (6)	See Eng. Controls	See Eng. Controls	See Eng. Controls	See Eng. Controls	See Eng. Controls	See Eng. Controls	See Eng. Controls	See Eng. Controls
Applying Sprays with a Fogger (7)	thermal fogger (mosquitoes)	NA	NA	NA	NA	NA	NA	NA
	non-termal fogger (mosquitoes)	0.22	0.50	100	0.9	0.0020	13,000	100

Table 6: Occupational Handler Short-term and Intermediate-term Risks from Malathion with Additional PPE. (continued)

Exposure Scenario (Scenario #)	Crop Type or Target	Dermal - Additional PPE.			Inhalation - Additional PPE.			Total - Additional PPE.
		Unit Exposure (mg/lb ai)[a]	Daily Dose (mg/kg/day)[b]	MOE[c]	Unit Exposure (µg/lb ai)[a]	Daily Dose (mg/kg/day)[d]	MOE[e]	Total MOE[f]
Applying Dusts with a Power Duster (8)	stored grain facility	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Dipping Plants (9)	grape root dip	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Applying with Handgun (turf) Sprayer (10)	turf	0.34 (Gloves only)	0.21	240	1.4 (No respirator)	0.00087	30,000	240
Mixer/Loader/Applicator Exposure								
Mixing/Loading/Applying with a Low Pressure Handwand (11)	stored grain facility	0.43 (Gloves only)	0.06	810	30 (No respirator)	0.0043	6000	700
	agricultural premises		0.07	750		0.0046	5600	660
	ornamentals		0.0064	7800		0.00045	58,000	6900
	turf		0.012	4200		0.00084	31,000	3700
Mixing/Loading/Applying with a Backpack Sprayer (12)	stored grain facility	2.5 (Gloves only)	0.36	140	30 (No respirator)	0.0043	6000	140
	agricultural premises		0.39	130		0.0046	5600	130
	ornamentals		0.037	1400		0.00045	58,000	1400
	turf		0.07	700		0.00084	31,000	700

Table 6: Occupational Handler Short-term and Intermediate-term Risks from Malathion with Additional PPE. (continued)

Exposure Scenario (Scenario #)	Crop Type or Target	Dermal - Additional PPE.			Inhalation - Additional PPE.			Total - Additional PPE.
		Unit Exposure (mg/lb ai)[a]	Daily Dose (mg/kg/day)[b]	MOE[c]	Unit Exposure (µg/lb ai)[a]	Daily Dose (mg/kg/day)[d]	MOE[e]	Total MOE[f]
Mixing/Loading/Applying with a Hose End Sprayer (13)	mushrooms	NA	NA	NA	NA	NA	NA	NA
Mixing/Loading/Applying with a Paintbrush (14)	mosquitoes	24 (Gloves only)	0.17	290	280 (No respirator)	0.002	13,000	280
Flagger Exposure								
Flagging for Aerial Spray Applications (15)	ag low	NA	NA	NA	NA	NA	NA	NA
	ag medium	NA	NA	NA	NA	NA	NA	NA
	ag high	NA	NA	NA	NA	NA	NA	NA
	citrus	NA	NA	NA	NA	NA	NA	NA
	pine trees	NA	NA	NA	NA	NA	NA	NA
	turf	0.010 (coveralls only)	0.44	115	0.35 (no respirator)	0.015	1700	110
	ULV ag crops	NA	NA	NA	NA	NA	NA	NA
	mosquitoes	NA	NA	NA	NA	NA	NA	NA

Table 6: Occupational Handler Short-term and Intermediate-term Risks from Malathion with Additional PPE. (continued)

Exposure Scenario (Scenario #)	Crop Type or Target	Dermal - Additional PPE.			Inhalation - Additional PPE.			Total - Additional PPE.
		Unit Exposure (mg/lb ai)[a]	Daily Dose (mg/kg/day)[b]	MOE[c]	Unit Exposure (µg/lb ai)[a]	Daily Dose (mg/kg/day)[d]	MOE[e]	Total MOE[f]
	ULV mosquitoes	NA	NA	NA	NA	NA	NA	NA

[a] Except where indicated in the Table, additional PPE. for all scenarios includes DOUBLE layer of clothing), chemical resistant gloves, and dust/mist respirator (5-fold PF).
[b] Daily Dermal Dose (mg/kg/day) is calculated using PPE. unit exposure and exposure algorithms presented in Table 1.
[c] Dermal MOE = NOEL (50 mg/kg/day)/ Daily Dermal Dose (mg/kg/day).
[d] Daily Inhalation Dose (mg/kg/day) is calculated using PPE. unit exposure and exposure algorithms presented in Table 1.
[e] Inhalation MOE = NOEL (25.8 mg/kg/day) / (Daily Inhalation Dose (mg/kg/day).
[f] Total MOE (short- and Intermediate-term) = 1 / ((1/Dermal MOE) + (1 /Inhalation MOE)).
NF Not Feasible
NA Not Applicable - Because previous level of mitigation resulted in total MOE $\geq$100.

Table 7: Occupational Handler Short-term and Intermediate-term Risks from Malathion with Engineering Controls

Exposure Scenario (Scenario #)	Crop Type or Target	Dermal - Engineering Controls			Inhalation - Engineering Controls			Total - Eng. Controls
		Unit Exposure (mg/lb ai)[a]	Daily Dose (mg/kg/day)[b]	MOE[c]	Unit Exposure (µg/lb ai)[a]	Daily Dose (mg/kg/day)[d]	MOE[e]	Total MOE[f]
Mixer/Loader Exposure								
Mixing/Loading Liquids for Groundboom Application (1a)	ag low, ag medium,, ag high, golf course turf, sod farms & ornamentals	NA	NA	NA	NA	NA	NA	NA
Mixing/Loading Liquids for Aerial and Chemigation Application (1b)	ag low, ag medium, ag high, pine trees, ULV ag crops, mosquitoes and ULV mosquitoes	NA	NA	NA	NA	NA	NA	NA
	citrus	0.0086	0.27	190	0.083	0.0026	10,000	190
	turf		0.37	130		0.0036	7100	130
Mixing/Loading Liquids for Airblast Sprayer (1c)	ag (fruit & nut)	NA	NA	NA	NA	NA	NA	NA
	ag (citrus fruit), & ornamentals							
Mixing/Loading Liquids for Dipping (1d)	grape root dip	NA	NA	NA	NA	NA	NA	NA
Mixing/Loading Liquids for a Fogger (truck) (1e)	thermal fogger (mosquitoes)	NA	NA	NA	NA	NA	NA	NA
	non-thermal fogger (mosquitoes)							
Mixing/Loading Liquids for a Handgun (1f)	turf	NA	NA	NA	NA	NA	NA	NA
Loading Dusts for Power Duster or Direct Application (2)	stored grain facility	NA	NA	NA	NA	NA	NA	NA
Mixing/Loading Wettable Powders for Groundboom Application (3a)	berries	NA	NA	NA	NA	NA	NA	NA
Mixing/Loading Wettable Powders for Aerial Application (3b)	berries	0.0098	0.098	510	0.24	0.0024	11,000	490
Mixing/Loading Wettable Powders for Airblast Sprayer (3c)	berries	NA	NA	NA	NA	NA	NA	NA
Applicator Exposure								
Applying Sprays with an Airblast Sprayer (4)	citrus	0.019	0.068	740	0.45	0.0016	16,000	700
	stone fruits, ornamentals and pome fruits	NA	NA	NA	NA	NA	NA	NA

Table 7: Occupational Handler Short-term and Intermediate-term Risks from Malathion with Engineering Controls (continued)

Exposure Scenario (Scenario #)	Crop Type or Target	Dermal - Engineering Controls			Inhalation - Engineering Controls			Total - Eng. Controls
		Unit Exposure (mg/lb ai)[a]	Daily Dose (mg/kg/day)[b]	MOE[c]	Unit Exposure (µg/lb ai)[a]	Daily Dose (mg/kg/day)[d]	MOE[e]	Total MOE[f]
Applying Sprays with a Groundboom Sprayer (5)	ag low, ag medium, ag high, golf course turf, sod farm and ornamentals	NA	NA	NA	NA	NA	NA	NA
Applying Sprays with a Fixed-Wing Aircraft (liquid formulations) (6)	ag low	0.0050	0.031	1600	0.068	0.00043	61,000	1600
	ag medium		0.05	1000		0.00068	38,000	970
	ag high		0.13	400		0.0017	15,000	390
	citrus		0.16	320		0.0021	12,000	310
	pine trees		0.063	800		0.00085	30,000	780
	turf		0.22	230		0.0030	8700	220
	ULV ag crops		0.11	480		0.0014	18,000	470
	mosquitoes		0.054	930		0.00073	35,000	910
	ULV mosquitoes		0.12	410		0.0017	15,000	400
Applying Sprays with a Fogger (7)	thermal fogger (mosquitoes)	NA	NA	NA	NA	NA	NA	NA
	non-thermal fogger (mosquitoes)		NA	NA		NA	NA	NA
Applying Dusts with a Power Duster (8)	stored grain facility	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Dipping Plants (9)	grape root dip	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Applying with Handgun (turf) Sprayer (10)	turf	NA	NA	NA	NA	NA	NA	NA
Mixer/Loader/Applicator Exposure								
Mixing/Loading/Applying with a Low Pressure Handwand (11)	stored grain facility, agricultural premises, ornamentals and turf	None	NF	NF	None	NF	NF	NF
Mixing/Loading/Applying with a Backpack Sprayer (12)	stored grain facility, agricultural premises, ornamentals and turf	None	NF	NF	None	NF	NF	NF

Table 7: Occupational Handler Short-term and Intermediate-term Risks from Malathion with Engineering Controls (continued)

Exposure Scenario (Scenario #)	Crop Type or Target	Dermal - Engineering Controls			Inhalation - Engineering Controls			Total - Eng. Controls
		Unit Exposure (mg/lb ai)[a]	Daily Dose (mg/kg/day)[b]	MOE[c]	Unit Exposure (µg/lb ai)[a]	Daily Dose (mg/kg/day)[d]	MOE[e]	Total MOE[f]
Mixing/Loading/Applying with a Hose End Sprayer (13)	mushrooms	None	NF	NF	None	NF	NF	NF
Mixing/Loading/Applying with a Paintbrush (14)	mosquitoes	None	NF	NF	None	NF	NF	NF
Flagger Exposure								
Flagging for Aerial Spray Applications (15)	ag low, ag medium, ag high, citrus, pine trees, turf, ULV ag crops, mosquitoes, ULV mosquitoes	NA	NA	NA	NA	NA	NA	NA

Footnotes:

[a] Engineering Controls:
1b/1c/1d/1e: Closed mixing/loading, single layer clothing, chemical resistant gloves.
3: Water soluble packets
4: Enclosed cab, single layer clothing, gloves. Note that a "no gloves" scenario was not available in PHED. However, gloves do no contribute significant protection in an enclosed cab and therefore a back-calculation (i.e., 90% reduction factor for hand exposure) was not used to determine a "no gloves" scenario.
6: Enclosed cockpit, single layer clothing, no gloves.
7: Enclosed cockpit, single layer clothing, no gloves.
8: Enclosed cab, single layer clothing, no gloves.
15: Enclosed cab, single layer clothing, no gloves.

[b] Daily Dermal Dose (mg/kg/day) = Daily Dermal Exposure (mg/day)/ Body weight (70 kg).

[c] Dermal MOE = NOEL (50 mg/kg/day)/ Daily Dermal Dose (mg/kg/day).

[d] Daily Inhalation Dose (mg/kg/day) = Daily Inhalation Exposure (mg/day)/ Body weight (70 kg).

[e] Inhalation MOE = NOEL (25.8 mg/kg/day)/ Daily Inhalation Dose (mg/kg/day).

[f] Total MOE (short- and Intermediate-term) = 1 / ((1/Dermal MOE) + (1 /Inhalation MOE)).

NF Not Feasible

NA Not Applicable - Because previous level of mitigation resulted in total MOE ≥100.

2.1.4 Handler Exposure and Risk Estimates for Cancer

In accordance with the EPA *Proposed Guidelines for Carcinogen Risk Assessment* (July 1999), the Cancer Assessment Review Committee at the 12-April-2000 meeting, classified malathion as **"suggestive evidence of carcinogenicity but not sufficient to assess human carcinogenic potential"** by all routes of exposure. **Quantitative risk assessment for carcinogenicity is NOT required** since the Committee classified malathion as having suggestive evidence for cancer. A cancer dose-response assessment, e.g., a low dose linear extrapolation model, is not indicated for pesticides in the "suggestive"category.

2.1.5 Summary of Occupational Handler Risk Concerns, Data Gaps, and Confidence in Exposure and Risk Estimates

Summary of Short- and Intermediate-Term Risks

There are two toxicological endpoints for short-term and intermediate-term exposures. Risks for cholinesterase inhibition were calculated for dermal exposure and for the combined risk (Total MOE) from dermal and inhalation exposure (target MOE =100). Risk for histopathology in respiratory epithelium was calculated for inhalation exposure (target MOE =1000). A chronic risk assessment was not completed for the handlers because the use patterns do not indicate any chronic exposure patterns. Cholinesterase inhibition drives the risk from malathion exposure and, therefore, the summary of occupational handler risks below is for this toxicological endpoint.

Handler Scenarios with Risk Outcomes. The calculations indicate that the total MOE (which includes both dermal and inhalation exposure) is greater than, or equal to 100 at **baseline** for the following scenarios:

- (1d) mixing/loading liquids for dipping
- (2) mixing/loading dusts for power duster or direct application (grain)
- (4) applying sprays with an airblast sprayer (pome fruits)
- (5) applying sprays with a groundboom sprayer (all use sites).
- (7) applying outdoor sprays with a thermal fogger (mosquitoes).
- (13) mixing/loading/applying with a hose end sprayer (mushrooms) .
- (15) flagging aerial spray applications (all use sites except turf).

The calculations indicate that the total MOE (which includes both dermal and inhalation exposure) is greater than, or equal to 100 with additional **PPE *** for the following scenarios:

- (1a) mixing/loading liquids for groundboom application (all use sites - *gloves only*, *no respirator*).
- (1b) mixing/loading liquids for aerial and chemigation application (ag low, ag medium, pine trees, ULV ag crops, and mosquitoes - *no respirator*; ag high and ULV mosquitoes).
- (1c) mixing/loading liquids for airblast sprayer (all use sites - *no respirator*, *gloves only*).
- (1e) mixing/loading liquids for a thermal or non-thermal fogger (mosquitoes - *gloves only, no respirator*).
- (1f) mixing/loading liquids for handgun (turf - *no respirator*, *gloves only*).
- (3a) mixing/loading wettable powders for groundboom (berries).
- (3c) mixing/loading wettable powders for airblast sprayer (berries).
- (4) applying sprays with an airblast sprayer (stone fruits, ornamentals and pome fruits -*no respirator*).
- (7) applying sprays with a non-thermal fogger (mosquitoes).
- (10) applying handgun sprayer (turf - *gloves only, no respirator*).
- (11) mixing/loading/applying with a low pressure handwand (all use sites - *gloves only, no respirator*).
- (12) mixing/loading/applying with a backpack sprayer (all use sites - *gloves only, no respirator*).

- (14) mixing/loading/applying with paintbrush (mosquitoes -*gloves only, no respirator*).
- (15) flagging for aerial spray applications (turf - *coveralls only, no respirator*).

* Except where indicated in italics, additional PPE means double layer of clothing, chemical resistant gloves, and dust/mist respirator.

The calculations indicate that the total MOEs (which include both dermal and inhalation exposures) are greater than, or equal to 100 with additional **engineering controls** for the following scenarios:

- (1b) mixing/loading liquids for aerial and chemigation application (citrus and turf).
- (3b) mixing/loading wettable powders for aerial application (berries).
- (4) applying sprays with an airblast sprayer (citrus).
- (6) applying sprays with a fixed-wing aircraft (all use sites).

The calculations indicate that no Total MOE (which includes both dermal and inhalation exposures) is less than 100 (with the employment of some mitigation measures where needed).

Data Gaps. Data gaps exist for the following scenarios:

- (8) applying dusts with a power duster; no PHED data exist.
- (9) dipping plants; no PHED data exist.
- (12) mixing/loading/applying with a backpack sprayer; no PHED data exist for baseline.

Data Quality and Confidence in Assessment. Several issues must be considered when interpreting the occupational exposure risk assessment. These include:

- Several handler assessments were completed using “low quality” PHED data. The resulting uncertainty means that the actual risks could be greater, or less than the risks estimated with these data.

- Several generic protection factors were used to calculate handler exposures. The protection factors used in this assessment are generally accepted by HED, but have not been externally peer reviewed. Specific mitigation measures may yield greater or less protection than is assumed. The ones used are considered to be reasonable high-end estimates.

- Factors used to calculate daily exposures to handlers (e.g., acres treated per day, square feet applied, and gallons of liquid applied) are based on the best professional judgement of HED staff, but have not been externally peer reviewed.

- PHED mixer/loader data for wettable powder are used as a surrogate for dusts.

- PHED applicator data for airblast are used as a surrogate for fogger.

2.2 Occupational Post-Application Exposures and Risks

EPA has determined that there are potential intermediate-term occupational postapplication exposures to individuals entering treated fields and contacting malathion and malaoxon residues on plant surfaces. Only postapplication dermal exposure has been assessed because postapplication inhalation exposure is expected to be negligible. Workers are expected, generally, to be performing activities (harvesting or non-harvesting) in malathion-treated fields for at least seven or more consecutive workdays in a growing season, with some fields receiving repeat malathion applications at 7-10 day intervals. Because of the seasonal nature of malathion use, a long-term exposure scenario is not expected for field workers. Mushroom houses are a special case, where the

indoor, year long treatment and harvesting of multiple crop cycles result in the potential for mushroom house workers to experience long-term exposure to malathion (i.e. ≥180 days).

2.2.1Postapplication Exposure Scenarios

Postapplication exposure scenarios assessed for malathion were developed from the revised HED Exposure Science Advisory Council Policy (Policy 003 - revised August 7, 2000) on Agricultural Transfer Coefficients. Transfer coefficients are based primarily on data submitted by the Agricultural Reentry Task Force (ARTF) to the Agency or from published literature studies. Studies submitted by the ARTF are identified in the table below by ARF or MRID number. Data from these studies are proprietary and compensation issues with ARTF may need to be addressed. The crop groupings and activities were based in large part on the ARTF Scoping Survey. Occupational postapplication exposure scenarios, along with the transfer coefficients used in this assessment are as follows:

Exposure Scenario	Representative crops	Application Rate (lb ai/acre)	Reference	Activity	Transfer coefficient (cm^2/hour)
Berry, low	blueberries and strawberries	2.0	MRID#: 430130	hand harvesting, pruning and training	1500
Field / row crop, low/medium	alfalfa, barley, cotton, flax, forage plants, mint, peas (green and dry), rice and wheat (spring and winter)	2.5	ARF021	hand harvesting	2500
			MRID#: 426891	weeding, thinning, irrigation, scouting	100
Field / row crop, tall	corn (all types) and sorghum	1.25	ARF010	hand harvesting (sweet corn), detasseling (seed corn)	17,000
			ARF009	scouting, irrigating, hand weeding	1000
Trees, "fruit", deciduous	apples, apricots, cherry, figs, nectarines, peaches and pears	3.75	MRID#: 428300	hand harvesting	3000
			MRID#: 424281	thinning	8000
Trees, "fruit", evergreen	avacado, Christmas trees, grapefruit, lemons, mangos, oranges, and papaya	1.25 to 6.25	MRID#: 424281	hand harvesting	8000
			MRID#: 430627	hand pruning	3000
Tree, "nut"	macadamia nuts, pecans and walnuts	5.0	MRID#: 430627	hand harvesting, thinning	2500
Turf/sod	turf farms and golf courses	8.7	Revised HED Draft Residential SOPs	sod harvesting, hand weeding	16,500
ornamentals	nursery crops	2.5	HED Exposure SAC Policy 003, May 1998	transplant, ball/burlap	10,000
Vegetable, "root"	beets (table), carrots, onions (dry and green), potatoes, sweet potatoes and turnips	1.56	ARF021	hand harvesting, thinning	2500
			MRID#: 428513	scouting, irrigating	300
Vegetable, cucurbit	cantaloupe, cucumbers, squash (summer and winter), watermelon and pumpkin	1.88	ARF021	hand harvesting, pruning, thinning	2500
			ARF021	scouting, irrigating	500
Vegetable, fruiting	eggplant, peppers, tomatoes and okra	3.43	MRID#: 409665	hand harvesting, tying, pruning, thinning	1000
Vegetable, head and stem Brassica	broccoli, Brussels sprouts, cabbage and cauliflower	2.0	ARF021	hand harvesting, pruning, irrigation	5000

Vegetable, leafy	celery, collards, kale, lettuce, parsley, spinach, mustard greens, Swiss chard and watercress	2.0	ARF021	hand harvesting, pruning, thinning	2500
Vegetable, stem/stalk	asparagus and pineapple	1.25	MRID#: 409665	hand harvesting, pruning	1000
		5.0			
Vine / trellis	blackberries, blueberries, grapes and raspberries	2.0	MRID#: 409753	cane turning (table grapes)	10,000
			MRID#: 409856	hand harvesting, pruning, thinning	5,000
			ARF023	tying, training	1,000
Mushrooms	mushrooms	1.7	HED Exposure SAC Policy 003, May 1998	cutting and harvesting	2500
Bunch/bundle	hops	0.63	ARF024	harvesting, pruning, thinning, weeding	2000

2.2.2Basis and Approach for Assessment of Postapplication Scenarios

A transferable residue study on turf (MRID 441133-01) was conducted with malathion formulated as the end use product Malathion 57EC. This study examined the residue levels of malathion that could be transferred from treated turf. Four geographic sites were included in this study to represent the different use areas in the United States. These sites represented cool season grass in the Northeast/mid Atlantic, cool season grass in the Midwest, warm season grass in the South Atlantic/Gulf region, and warm season grass in the Pacific Coastal region.

At each site, one application of the 57EC, with a target rate of 5 lb ai per acre (4 quarts of formulated product in 100 gallons of water), was performed with hand-gun spray equipment. These conditions were meant to provide the maximum level of malathion residues. Sprinkler irrigations were performed within one hour of each application, providing approximately 0.1 inch of water.

Field data were collected from June to September 1995. A total of twelve transferable residue samples and three control samples were collected from each site (three samples collected from a subplot in each of the four treated plots and a control plot at each site). At most locations, samples were collected before and after application, then at 4, 8, 12, 24, and 72 hours after treatment. Transferable residues of malathion were quantified by placing cloth dosimeters on the turf. A 15-kg roller was then rolled over each dosimeter. After being shaken to remove foliage, dosimeters were stored and shipped frozen to the laboratory for analysis. The malathion parent compound was the analyte measured. Field recovery and laboratory recovery data were collected; however, storage stability samples were not examined.

For the purposes of this occupational post-application exposure assessment, a regression analysis was conducted using the (log transformed) turf transferrable residue (TTR) data from this study to estimate residue levels after 4, 8, 12, 24, 48, and 72 hours after treatment using the following equation:

$$y = mx + b$$

where:

x	=	hours after treatment;
m	=	slope of the regression line;
b	=	constant; and
y	=	residue at hour x.

Regression and data analyses were conducted to examine the dissipation data and to compare with the results of the study report. A comparison of reported analytical residue values and regression analysis data is presented in Table 11. For the Pennsylvania site, the average residue level was 1.22 ug/cm^2 at 0 hour, and declined to 0.0110 ug/cm^2 at 72 hours after treatment. The half-life was 12.1 hours. For the North Carolina site, the average residue level was 0.297 μg/cm^2 at 0 hour, and declined to less than the LOQ at 48 hours after treatment. The half life was 11.2 hours. For the Missouri site, the average level was 0.605 μg/cm^2 at 0 hour, and declined to less than the LOQ at 72 hours after treatment. The half-life was 13.8 hours. For the California site, the average residue level was 0.815 ug/cm^2 at 0 hour, and declined to 0.0159 ug/cm^2 at 72 hours after treatment. The half-life was 14.5 hours.

While the average coefficient of variability from each individual site ranged from 45.4 to 71.1, suggesting considerable data variability among treated plots, R^2 values for each regression model (site) ranged from 0.827 to 1.000, which suggests good model prediction of residue levels. Regarding the latter, an R^2 value of 1.000 resulted from performing the regression analysis for just two data points from the North Carolina site (i.e., data at 0 and 4 hours). A rain event was partially responsible for limiting the data at this site.

The dissipation curve generated by the regression analysis of the measured values in the turf study allows for the prediction of dislodgeable foliar residue (DFR) values beyond the period during which measurements were made and for application rates and crop activity transfer coefficients different from those for turf. The average half-life of malathion from the turf study was 13 hours. The dissipation at 13 hours is approximately 46%. The daily (24-hour) dissipation rate is approximately 72%.

Although the daily dissipation rate may be estimated at 72%, the more conservative 46% dissipation rate was used for calculation of MOEs at various reentry intervals for agricultural (i.e., non-turf) sites. The more conservative rate is used because the relationship between transferrable residues from the turf studies and dislodgeable foliar residues from agricultural crops is not fully known, and because the 13-hour rate more closely represents the dissipation expected to occur at the 12-hour REI currently appearing on malathion product labels. It should also be noted that in the turf study, the label-recommended use of irrigation shortly following the initial application was followed. This practice may result in diminishing the initial amount of residue available for transfer when compared to all other crops for which the data were used, and for which this practice is not followed. This uncertainty may add an underestimation component to the assessment. Postapplication risks for turf used 1.3% of the application rate as the initial amount of residue available for transferring to skin, as predicted by the regression analysis based on the actual TTR value measured immediately after application (0 hour) in the turf study. For all other crop types, the HED standard value for initial DFR (20%) was used.

In summary, the transferable residue study completed in support of malathion only partially met the criteria contained in Subdivison K of the Pesticide Assessment Guidelines. The conclusion was based on the following issues of concern: (1) a considerable variability in the reported DFR residues reported in each site (e.g., the average coefficient of variability from each individual site ranged from 45.4% to 71.1%); (2) the label information was not provided in the study report, so it was not clear whether the maximum label rate of 5 lb ai per acre was appropriate. As identified in the handler section of this report, some malathion labels for turf products indicate a label rate of 8.7 lb ai per acre; (3) information as to the actual agricultural practices for turf (e.g, irrigation) were not identifiable because of the lack of label information; (4) the study samples were stored up to 14 days (from the day of sampling to the day of analysis); however, storage stability was not examined; (5) the study describes an irrigation practice which may cause an underestimation of the initial residue concentration; and (6) insufficient samples were collected at the North Carolina site; only 0, 4, 24, and 48 hour postapplication samples were collected, and a considerably large number of less-than-LOQ results were obtained, which may have been due to a significant rain event that ocurred shortly after application. It was concluded, however, that none of the above deficiencies was sufficient to preclude the use of the results from the turf study in this assessment.

It should be further noted that this assessment of the potential postapplication exposure to malathion reflects residue of malathion *per se.* Information specific to the potential formation of malaoxon following uses subject to this reregistration action has not been submitted. Monitoring data used in the assessment of malathion bait spray in the California medfly eradication program (Bradman, M.A.,et al., 1994) indicates the postapplication formation of the oxidative breakdown product, malaoxon at levels an order of magnitude less than the parent compound on plant surfaces. Although aware of the possible formation of malaoxon following the uses subject to this reregistration action, there is insufficient information currently available to perform a quantitative exposure assessment without a large degree of uncertainty. Therefore, an assessment of the potential postapplication exposure to malaoxon has not been performed, and in order to do so would require the results from malathion/malaoxon residue dissipation studies for representative crops.

Table 11: Malathion Residues Following Application of Malathion 57EC at 5 lb ai/A to Turfgrass.

Hours after treatment	Pennsylvania Transferrable Residues (µg/cm^2) Reported [Predicted[a]]	North Carolina Transferrable Residues (µg/cm^2) Reported [Predicted[a]]	Missouri Transferrable Residues (µg/cm^2) Reported [Predicted[a]]	California Transferrable Residues (µg/cm^2) Reported [Predicted[a]]	Average Transferrable Residues (µg/cm^2) Reported [Predicted[a]]
0	1.22 [0.648]	0.297 [0.0596]	0.605 [0.0880]	0.815 [0.420]	0.73 [0.30]
4	0.424 [0.515]	0.0131 [0.0465]	0.0466 [0.0721]	0.203 [0.347]	0.17 [0.25]
8	ND [0.409]	ND [0.0363]	ND [0.0590]	0.137 [0.286]	0.137 [0.20]
12	0.415 [0.325]	ND [0.0284]	0.0244 [0.0483]	0.536 [0.236]	0.325 [0.16]
24	0.0481 [0.163]	0.00548 [0.0135]	0.00760 [0.0265]	0.112 [0.133]	0.043 [0.084]
48	0.0657 [0.041]	< LOQ [0.00305]	<LOQ [0.00799]	0.0336 [0.0421	0.05 [0.024]
72	0.0110 [0.0103]	ND [0.000691]	<LOQ [0.00241]	0.0159 [0.0133]	0.013 [0.0067]
Half-Life (hours)	12.1	11.2	13.8	14.5	12.9
R^2 Value	0.859	1.000	0.830	0.827	
Ave. Coefficient of Variation (CV)	47.8	45.4	71.1	51.5	

a Predicted transferrable residue (ug/cm^2) = Exp $^{(\text{intercept + slope x time})}$
ND No Data
<LOQ = Less than limit of quantitation.

2.2.3Occupational Postapplication Exposure and Risk Assessment

The surrogate assessments presented in Table 12 are based on the crop grouping, application rate, activity and transfer coefficient scenarios presented in section 2.2.1 above. These scenarios are believed to bracket the reentry exposure levels anticipated from use rates for registered crop sites. The DFR is derived from the application rates for these crops, using an estimated 1.3 percent of the rate applied as initial amount of transferrable residue for turf uses (based on predicted residue value at time 0 in the turf study),and using 20 percent of the rate as the initial amount of dislodgeable residue for all other (non-turf) uses.

The equations used for the calculations in Table 12 are presented below:

$$\text{DFR}\left(\frac{\mu\text{g}}{\text{cm}^2}\right) = \text{AR}\left(\frac{\text{lb ai}}{\text{acre}}\right) \text{ x } \text{CF}\left(\frac{\mu\text{g/cm}^2}{\text{lb ai/acre}}\right) \text{ x F x } (1 - \text{DR})^t$$

Where:
DFR = Dislodgeable foliar residue (μg/cm^2),
AR = Application rate (lb ai/acre),
CF = Conversion factor (11.2 μg/cm^2 per lb ai/acre),
F = Fraction retained on foliage (1.3 percent for turf; 20 percent for all other uses),
DR = Daily dissipation rate (72 percent/day for turf; 46 percent for all non-turf uses),
t = Days after treatment.

$$\text{Dose (mg/kg/day)} = \frac{(\text{DFR } (\mu\text{g/cm}^2) \text{ x Tc } (\text{cm}^2\text{/hr}) \text{ x CF } (0.001 \text{ mg/}\mu\text{g}) \text{ x ED (hr/day)) x Abs (\%/100)}}{\text{BW (kg)}}$$

Where:
Tc = Transfer coefficient (cm^2/hr),
CF = Conversion factor (0.001 mg/μg),
Abs = Absorption (10% dermal absorption; applies only to long-term exposure)
ED = Exposure duration (8 hours worked per day), and
BW = Body weight (70 kg).

MOE = NOAEL (mg/kg/day) ÷ Dose (mg/kg/day

Where:
NOAEL = 50 mg/kg/day (short and intermediate-term) or 2.4 mg/kg/day (long-term)
Dose = Calculated dose.

Table 12: Malathion Short- and Intermediate-Term Surrogate Postapplication Assessment

DAT[a]	DFR (μg/cm^2)[b]	Dermal Dose (mg/kg/day)[c]	MOE[d]
Berry, low (2.0 lb ai/acre) Tc = 1500			
0	4.5	0.77	65
1	2.4	0.42	120
Field/row crop, low/medium (2.5 lb ai/acre) Tc = 2500			
0	5.6	1.6	31
1	3.0	0.86	58
2	1.6	0.47	107
Field/row crop, low/medium (2.5 lb ai/acre) Tc = 100			
0	5.6	0.06	780
Field/row crop, tall (1.25 lb ai/acre) Tc = 17,000			
0	2.8	5.4	9
1	1.5	2.9	17
2	0.8	1.5	31
3	0.4	0.9	58
4	0.2	0.5	108

DAT[a]	DFR (μg/cm^2)[b]	Dermal Dose (mg/kg/day)[c]	MOE[d]
Field/row crop, tall (1.25 lb ai/acre) Tc = 1000			
0	2.8	0.3	160
Trees, "fruit", deciduous (3.75 lb ai/acre) Tc = 8000			
0	8.4	7.7	7
1	4.5	4.2	12
2	2.5	2.2	22
3	1.3	1.2	41
4	0.7	0.65	77
5	0.4	0.35	140
Trees, "fruit", deciduous (3.75 lb ai/acre) Tc = 3000			
0	8.4	2.9	17
1	4.5	1.6	32
2	2.5	0.84	59
3	1.3	0.45	110
Trees, "fruit", evergreen (6.25 lb ai/acre) Tc = 8000			
0	14	12.8	4
1	7.6	6.9	7
2	4.1	3.7	13
3	2.2	2.0	25
4	1.2	1.1	46
5	0.6	0.6	85
6	0.3	0.3	160
Trees, "fruit", evergreen (6.25 lb ai/acre) Tc = 3000			
0	14	4.8	10
1	7.6	2.6	19
2	4.1	1.4	36
3	2.2	0.76	66
4	1.2	0.41	120
Trees, "fruit", evergreen (1.25 lb ai/acre) Tc = 8000			
0	2.8	2.6	20
1	1.5	1.4	36
2	0.8	0.75	67
3	0.4	0.40	120

DAT[a]	DFR (μg/cm^2)[b]	Dermal Dose (mg/kg/day)[c]	MOE[d]
Trees, "fruit", evergreen (1.25 lb ai/acre) Tc = 3000			
0	2.8	0.96	52
1	1.5	0.52	96
2	0.8	0.28	180
Tree, "nut" (5.0 lb ai/acre) Tc = 2500			
0	11	3.2	16
1	6.1	1.7	29
2	3.3	0.93	54
3	1.8	0.50	99
4	1.0	0.27	180
Turf/sod (8.7 lb ai/acre) Tc = 16,500			
0	1.3	2.4	21
1	0.4	0.67	75
2	0.1	0.19	270
Ornamentals (2.5 lb ai/acre) Tc = 10,000			
0	5.6	6.4	8
1	3.0	3.5	14
2	1.6	1.9	27
3	0.9	1.0	50
4	0.5	0.54	92
5	0.3	0.29	170
Vegetable, "root" (1.56 lb ai/acre) Tc = 2500			
0	3.5	0.99	50
1	1.9	0.54	93
2	1.0	0.29	172
Vegetable, "root" (1.56 lb ai/acre) Tc = 500			
0	3.5	0.20	250
Vegetable, cucurbit (1.88 lb ai/acre) Tc = 2500			
0	4.2	1.2	42
1	2.3	0.65	77
2	1.2	0.35	142

DAT[a]	DFR (μg/cm^2)[b]	Dermal Dose (mg/kg/day)[c]	MOE[d]
Vegetable, cucurbit (1.88 lb ai/acre) Tc = 500			
0	4.2	0.24	208
Vegetable, fruiting (3.43 lb ai/acre) Tc = 1000			
0	7.7	0.88	57
1	4.2	0.47	105
Vegetable, head and stem Brassica (2.0 lb ai/acre) Tc = 5000			
0	4.5	2.6	20
1	2.4	1.4	36
2	1.3	0.75	67
3	0.7	0.40	124
Vegetable, leafy (2.0 lb ai/acre) Tc - 2500			
0	4.5	1.3	39
1	2.4	0.69	72
2	1.3	0.37	134
Vegetable, stem/stalk (1.25 lb ai/acre) Tc = 1000			
0	2.8	0.32	156
Vegetable, stem/stalk (5.0 lb ai/acre) Tc = 1000			
0	11	1.3	39
1	6.1	0.69	72
2	3.3	0.37	134
Vine/trellis (2.0 lb ai/acre) Tc = 10,000			
0	4.5	5.1	10
1	2.4	2.8	18
2	1.3	1.5	33
3	0.7	0.81	62
4	0.4	0.44	115
Vine/trellis (2.0 lb ai/acre) Tc = 5,000			
0	4.5	2.6	20
1	2.4	1.4	36
2	1.3	0.75	67
3	0.7	0.40	124

DAT[a]	DFR (μg/cm^2)[b]	Dermal Dose (mg/kg/day)[c]	MOE[d]
Vine/trellis (2.0 lb ai/acre) Tc = 1,000			
0	4.5	0.51	98
1	2.4	0.28	180
Mushrooms (1.7 lbs ai/acre) Tc = 2500			
0	3.8	1.1	46
1	2.1	0.59	85
2	1.1	0.32	157
Bunch/bundle (hops at 0.63 lbs ai/acre) Tc = 2000			
0	1.4	0.32	160

a DAT is "days after treatment."
b Initial DFR = Application Rate x Conversion Factor (11.209 μg/cm^2 lb ai/acre) x Fraction of initial ai retained on foliage (1.3% for turf; 20% for other uses) x (1- daily dissipation rate (46%)^{time}.
c Dose (mg/kg/day)= [DFR (ug/cm^2) x Tc (cm^2/hr) x Conversion factor (1 mg/1000 µg) x hrs worked per day (hrs)]/Body Weight (kg);
d MOE = NOAEL (mg/kg/day)/Dose (mg/kg/day); where NOAEL is 50 mg/kg/day based on a dermal study.

2.2.4 Summary of Occupational Postapplication Risk, Data Gaps and Confidence in Exposure and Risk Estimates

Short- and Intermediate-Term Risk

The target MOE is 100 for malathion. The resulting short- and intermediate-term surrogate occupational postapplication assessment for malathion, indicates that:

- MOEs equal or exceed 100 for **berries** on the **1st day** following application at a rate of 2.0 pounds active ingredient per acre. (Tc = 1500 cm^2/hr for hand harvesting, pruning and training)
- MOEs equal or exceed 100 for **field/row crop, low/medium**, on the **2nd day** following application at a rate of 2.5 pounds active ingredient per acre. (Tc = 2500 cm^2/hr for hand harvesting)
- MOEs equal or exceed 100 for **field/row crop, low/medium**, on the **same day** of application following application at a rate of 2.5 pounds active ingredient per acre. (Tc = 100 cm^2/hr for weeding, thinning, irrigation and scouting)
- MOEs equal or exceed 100 for **field/row crop, tall,** on the **4th day** following application at a rate of 1.5 pounds active ingredient per acre. (Tc = 17,000 cm^2/hr for hand harvesting and detasseling corn)
- MOEs equal or exceed 100 for **field/row crop, tall**, on the the **same day** of application at a rate of 1.5 pounds active ingredient per acre. (Tc = 1000 cm^2/hr for scouting, irrigating and hand weeding)
- MOEs equal or exceed 100 for **deciduous fruit trees** on the **3rd day** following application at a rate of 3.75 pounds active ingredient per acre. (Tc = 3000 cm^2/hr for hand harvesting)
- MOEs equal or exceed 100 for **deciduous fruit trees** on the **5th day** following application at a rate of 3.75 pounds active ingredient per acre. (Tc = 8000 cm^2/hr for thinning)
- MOEs equal or exceed 100 for **evergreen fruit trees** on the **6th day** following application at a rate of 6.25 pounds active ingredient per acre. (Tc = 8000 cm^2/hr for hand harvesting)

- MOEs equal or exceed 100 for **evergreen fruit trees** on the **4th day** following application at a rate of 6.25 pounds active ingredient per acre. (Tc = 3000 cm^2/hr for hand pruning)
- MOEs equal or exceed 100 for **evergreen fruit trees** on the **3rd day** following application at a rate of 1.25 pounds active ingredient per acre. (Tc = 8000 cm^2/hr for hand harvesting)
- MOEs equal or exceed 100 for **evergreen fruit trees** on the **2nd day** following application at a rate of 1.25 pounds active ingredient per acre. (Tc = 3000 cm^2/hr for hand pruning)
- MOEs equal or exceed 100 for **nut trees** on the **4th day** following application at a rate of 5.0 pounds active ingredient per acre. (Tc = 2500 cm^2/hr for hand harvesting and thinning)
- MOEs equal or exceed 100 for **turf/sod** on the **2nd day** following application at a rate of 8.7 pounds active ingredient per acre. (Tc = 16,500 cm^2/hr for sod harvesting and hand weeding)
- MOEs equal or exceed 100 for **ornamentals** on the **5th day** following application at a rate of 2.5 pounds active ingredient per acre. (Tc = 10,000 cm^2/hr for transplanting, ball/burlapping)
- MOEs equal or exceed 100 for **root vegetables** on the **2nd day** following application at a rate of 1.56 pounds active ingredient per acre. (Tc = 2500 cm^2/hr for hand harvesting and thinning)
- MOEs equal or exceed 100 for **root vegetables** on the **same day** of application at a rate of 1.56 pounds active ingredient per acre. (Tc = 500 cm^2/hr for scouting and irrigating)
- MOEs equal or exceed 100 for **cucurbit vegetables** on the **2nd day** of application at a rate of 1.88 pounds active ingredient per acre. (Tc = 2500 cm^2/hr for hand harvesting, pruning and thinning)
- MOEs equal or exceed 100 for **cucurbit vegetables** on the **same day** of application at a rate of 1.88 pounds active ingredient per acre. (Tc = 500 cm^2/hr for scouting and irrigating)
- MOEs equal or exceed 100 for **fruiting vegetables** on the **1st day** following application at a rate of 3.43 pounds active ingredient per acre. (Tc = 1000 cm^2/hr for hand harvesting, tying, pruning and thinning)
- MOEs equal or exceed 100 for **head and stem Brassica vegetables** on the **3rd day** following application at a rate of 2.0 pounds active ingredient per acre. (Tc = 5000 cm^2/hour for hand harvesting, pruning and irrigation)
- MOEs equal or exceed 100 for **leafy vegetables** on the **2nd day** following application at a rate of 2.0 pounds active ingredient per acre. (Tc = 2500 cm^2/hour for hand harvesting, pruning and thinning)
- MOEs equal or exceed 100 for **stem/stalk vegetables** on the **same day** of application at a rate of 1.25 pounds active ingredient per acre. (Tc = 1000 cm^2/hour for hand harvesting and pruning)
- MOEs equal or exceed 100 for **stem/stalk vegetables** on the **2nd day** following application at a rate of 5.0 pounds active ingredient per acre. (Tc = 1000 cm^2/hour for hand harvesting and pruning)
- MOEs equal or exceed 100 for **vine/trellis crops** on the **4th day** following application at a rate of 2.0 pounds active ingredient per acre. (Tc = 10,000 cm^2/hour for cane turning table grapes)
- MOEs equal or exceed 100 for **vine/trellis crops** on the **3rd day** following application at a rate of 2.0 pounds active ingredient per acre. (Tc = 5000 cm^2/hour for hand harvesting, pruning and thinning)

- MOEs equal or exceed 100 for **vine/trellis crops** on the **1st day** following application at a rate of 2.0 pounds active ingredient per acre. (Tc = 1000 cm^2/hour for tying and training)

- MOEs equal or exceed 100 for **mushrooms** on the **2nd day** following application at a rate of 1.7 pounds active ingredient per acre. (Tc = 2500 cm^2/hr for cutting and harvesting)

- MOEs equal or exceed 100 for **bunch/bundle crops** on the **same day** of application at a rate of 0.63 pounds active ingredient per acre. (Tc = 2000 cm^2/hr for harvesting, pruning, thinning and weeding)

Chronic Risk

The only chronic occupational postapplication scenario is for handling mushrooms (cutting, harvesting, sorting and packing) from beds that have been treated with malathion. It is assumed that a worker is engaged in such work for 180 days per year. The long-term endpoint is a 2.4 mg/kg/day NOAEL from a from a two-year feeding study. A dermal equivalent dose (using a 10% dermal absorption factor) of 24 mg/kg/day was used in the calculation. The resulting chronic surrogate postapplication assessment for malathion indicates that:

- MOEs equal or exceed 100 (i.e., 140) for **harvesting** activities associated with applications to **mushrooms** on the **3rd day** following application at a rate of 1.7 lb ai/acre: Tc = 2500 cm^2/hr. [Note that this is longer than for the short and intermediate risks]

Based on the occupational postapplication risks determined by the surrogate agricultural assessment, reentry is of concern on the same day as application (12 hours following treatment) for all exposure scenarios except for **field/row crop, low/medium** at a rate of 2.5 pounds active ingredient per acre (Tc = 100 cm^2/hr for weeding, thinning, irrigation and scouting); **field/row crop, tall** at a rate of 1.5 pounds active ingredient per acre (Tc = 1000 cm^2/hr for scouting, irrigating and hand weeding); **root vegetables** at a rate of 1.56 pounds active ingredient per acre (Tc = 500 cm^2/hr for scouting and irrigating); **cucurbit vegetables** at a rate of 1.88 pounds active ingredient per acre (Tc = 500 cm^2/hr for scouting and irrigating); **stem/stalk vegetables** at a rate of 1.25 pounds active ingredient per acre (Tc = 1000 cm^2/hour for hand harvesting and pruning); and, **bunch/bundle crops** at a rate of 0.63 pounds active ingredient per acre (Tc = 2000 cm^2/hr for harvesting, pruning, thinning and weeding). Because crops treated with malathion have an existing REI of 12 hours, HED has a concern over occupational postapplication risk.

Data Gaps

The surrogate assessment was performed with a 72 % daily dissipation rate for turf/sod and a 46% dissipation rate for all other crop use sites. The 46% rate is based on the half-life of malathion on turf at 13 hours following application. This more conservative value was used for non-turf use sites, in large part, because of the unknown differences in behavior of the pesticide on turf versus on all other crop sites. The standard value used in surrogate assessments, when no other postapplication information is available, is a 10% daily dissipation rate. Even though these variables were derived from a transferrable residue study on turf, they are believed to be more appropriate and directly applicable to predicting DFR values for other crops than using the standard HED default assumption of a 10% per day dissipation rate. The value used for the initial amount of residue available to be transferred to workers for turf/sod use sites (i.e., 1.3% of application rate) was based on the average amount of transferrable residue found immediately following application of malathion in the turf study. For all other crop use sites, a standard value of 20% of the application rate was assumed to be the initially available residue.

Field studies to determine dislodgeable foliar residues on a variety of crops treated by malathion would be necessary to refine the postapplication risk.

3.0 RESIDENTIAL AND OTHER NON-OCCUPATIONAL EXPOSURES AND RISKS

3.1 Residential Handler Exposures and Risks

EPA has determined that residential and other non-occupational handlers are likely to be exposed during malathion use. The anticipated use patterns and current labeling indicate several major exposure scenarios, based on the types of equipment that potentially can be used to make malathion applications. These scenarios include:

(1a) mixing/loading/applying liquid with a low pressure handwand;
(1b) mixing/loading/applying wettable powder with a low pressure handwand;
(2) mixing/loading/applying liquid with a hose end sprayer;
(3) mixing/loading/applying liquid with a backpack sprayer;
(4) mixing/loading/applying liquid with a fogger; and
(5) mixing/loading/applying dust using a shaker can.

3.1.1 Residential Handler Exposure Scenarios - Data and Assumptions

Residential handler exposure assessments were completed by HED assuming a "baseline" exposure scenario (for homeowners, short sleeved shirt, short pants, shoes and socks, and no gloves or respirator). PHED values used to estimate daily unit exposure values were taken from the *Standard Operating Procedures (SOPs) for Residential Exposure Assessments (December 1997)*.[8] Table 15 summarizes the caveats and parameters specific to the surrogate data used for each scenario and corresponding exposure/risk assessment. The following assumptions and factors were used in order to complete this exposure assessment:

- Calculations were completed at the maximum application rates for specific crops recommended by the available malathion labels to cover the range of maximum risk levels associated with various use patterns. No use data were provided by the registrant concerning the actual application rates that are commonly used for malathion, though survey data indicates that it is common for homeowners to apply maximum rates.

- The duration of exposure is expected to be short-term (1-7 days) based on label directions for multiple applications of malathion to fruits, vegetables, ornamentals, lawns, and outdoor premises which may be made every 7 days "as necessary". The frequency of homeowner applications is not expected to result in a continuous exposure duration of 1 week to several months. None of the currently registered residential or other non-occupational uses would result in long-term exposures.

- Generally, the use of PPE and engineering controls are not considered acceptable options for products sold for use by homeowners.

- For the low pressure handwand and the backpack sprayer, an estimate of 5 gallons of spray per day for fruit trees, ornamentals, vegetable/small fruit gardens, and mosquitoes was used for the homeowner scenario.

- For the low pressure handwand, backpack sprayer, and hose end sprayer an estimate of 1,000 ft^2 was used for spot treatment of homeowner turf.

- For the hose end sprayer, an estimate of 5 gallons of spray per day for fruit trees, ornamentals, vegetable/small fruit gardens, and mosquitoes was used for the homeowner scenario.

3.1.2 Residential Handler Exposure and Risk Estimates

The calculations of daily dermal and inhalation exposure to malathion by handlers was used to calculate the daily dose, and hence the risks, to those handlers. Potential daily dermal exposure was calculated using the following formula:

$$Daily\ Dermal\ Exposure\left(\frac{mg\ ai}{day}\right) = Unit\ Exposure\left(\frac{mg\ ai}{lb\ ai}\right) x\ Use\ Rate\left(\frac{lb\ ai}{A}\right) x\ Daily\ Acres\ Treated\left(\frac{A}{day}\right)$$

A dermal absorption value was not needed for short- and intermediate-term dermal exposure because the dermal NOAEL was based on a 21-day dermal study.

Potential daily inhalation exposure was calculated using the following formula:

$$Daily\ Inhalation\ Exposure\left(\frac{mg\ ai}{day}\right) =$$
$$Unit\ Exposure\left(\frac{\mu g\ ai}{lb\ ai}\right) x\ Conversion\ Factor\left(\frac{1mg}{1{,}000\ \mu g}\right) x\ Use\ Rate\left(\frac{lb\ ai}{A}\right) x\ Daily\ Acres\ Treated\left(\frac{A}{day}\right)$$

A 100 percent inhalation absorption value is assumed.

The daily dermal and inhalation dose was calculated using a 70 kg body weight for all toxicity endpoints (i.e., short-term and intermediate-term) as follows:

$$Daily\ Inhalation\ Dose\left(\frac{mg\ ai}{kg/day}\right) = Daily\ Inhalation\ Exposure\left(\frac{mg\ ai}{day}\right) x\left(\frac{1}{Body\ Weight\ (kg)}\right)$$

$$Daily\ Dermal\ Dose\left(\frac{mg\ ai}{Kg/Day}\right) = Daily\ Dermal\ Exposure\left(\frac{mg\ ai}{Day}\right) x\left(\frac{1}{Body\ Weight\ (Kg)}\right)$$

The calculations of both the daily dermal dose and the daily inhalation dose of malathion received by handlers was used to calculate the short-term dermal and inhalation MOEs. The dermal MOE was calculated using a NOAEL of 50 mg/kg/day, and the inhalation MOE was calculated using a NOAEL of 25.8 mg/kg/day. The following formula describes the calculation of a dermal MOE:

$$Dermal\ MOE = \frac{NOEL\left(\frac{mg}{kg/day}\right)}{Dermal\ Daily\ Dose\left(\frac{mg}{kg/day}\right)}$$

The following formula describes the calculation of an inhalation MOE:

$$Inhalation\ MOE = \frac{NOEL\left(\frac{mg}{kg/day}\right)}{Inhalation\ Daily\ Dose\left(\frac{mg}{kg/day}\right)}$$

The target dermal MOE, including short-, intermediate and long-term exposure periods, is 100 for cholinesterase inhibition. The target inhalation MOE, including short-, intermediate and long-term exposure periods, is 1000 for histopathology in respiratory epithelium. Chronic exposure is not expected for handlers, and therefore is not assessed. The short- and intermediate-term dermal toxicity endpoint (i.e., cholinesterase inhibition) is also seen from inhalation exposure (NOAEL of 25.8 mg/kg/day). Contribution of inhalation exposure to cholinesterase inhibition is relatively insignificant compared to dermal exposure. However, because the effect of concern is the same, the exposure contributed from both dermal and inhalation routes are added together to give an indication of the combined risk for cholinesterase inhibition. Both routes have the same target MOE for cholinesterase inhibition (i.e., 100), however, since the NOAELs are different for dermal (50 mg/kg/day) and inhalation (25.8 mg/kg/day), the total risk (i.e., total MOE) for this effect is estimated by combining MOEs from each route.

In order to calculate a Total MOE, the reciprocals of the dermal and inhalation MOEs are combined and divided into 1. The above operations are represented as follows:

$$\text{Total MOE} = \frac{1}{\frac{1}{MOE_{dermal}} + \frac{1}{MOE_{inhalation}}}$$

A total MOE $\geq$ 100 (for cholinesterase inhibition) does not present a concern for handler exposure. Likewise, an inhalation MOE $\geq$ 1000 (for histopathology in respiratory epithelium) does not present a concern for handler exposure.

Residential dermal and inhalation exposures (developed using PHED Version 1.1 surrogate data) are presented in Table 13. The corresponding short-term risks are presented in Table 14. Table 15 presents the residential scenario descriptions used in this RED.

Table 13. Residential Handler Short-term Dermal and Inhalation Exposures to Malathion at Baseline.

Exposure Scenario (Scen. #)	Baseline Dermal Unit Exposure[a] (mg/lb ai)	Baseline Inhalation Unit Exposure[b] (μg/lb ai)	Maximum Application Rates[c] (lb ai/acre)	Crop Type or Target[d]	Amount Handled per Day[e]	Daily Dermal Exposure[f] (mg/day)	Daily Inhalation Exposure[g] (mg/day)
Mixer/Loader/Applicator Exposure							
Mixing/Loading/Applying Liquids with a Low Pressure Handwand (1a)	100	30	0.034 lb ai /gal	Fruit Tree	5 gallons	17	0.005
			0.034 lb ai /gal	Ornamentals	5 gallons	17	0.005
			0.18 lb ai /1000 sq. ft	Turf	1,000 ft^2	18	0.005
			0.023 ai lb/gal	Vegetable/Small fruit Garden	5 gallons	11	0.003
			0.1547 lb ai /gal	Mosquitoes (household pests)	5 gallons	77	0.023
Mixing/Loading/Applying Wettable Powder with a Low Pressure Handwand (1b)	250	1,100	0.010 lb ai /gal	Fruit Tree	5 gallons	13	0.055
			0.015 lb ai /gal	Ornamentals	5 gallons	19	0.083
			0.018 lb ai /gal	Vegetable/Small fruit Garden	5 gallons	23	0.099
Mixing/Loading/Applying Liquids with a Hose End Sprayer (2)	30	9.5	0.034 lb ai /gal	Fruit Tree	5 gallons	5.1	0.002
			0.034 lb ai /gal	Ornamentals	5 gallons	5.1	0.002
			0.18 lb ai /1000 sq. ft	Turf	1,000 ft^2	0.54	0.000
			0.023 lb ai /gal	Vegetable/Small fruit Garden	5 gallons	3.5	0.001
			0.1547 lb ai/gal	Mosquitoes (household pests)	5 gallons	23	0.007

Exposure Scenario (Scen. #)	Baseline Dermal Unit Exposure[a] (mg/lb ai)	Baseline Inhalation Unit Exposure[b] (μg/lb ai)	Maximum Application Rates[c] (lb ai/acre)	Crop Type or Target[d]	Amount Handled per Day[e]	Daily Dermal Exposure[f] (mg/day)	Daily Inhalation Exposure[g] (mg/day)
Mixing/Loading/Applying Liquids with Backpack Sprayer (3)	5.1	30	0.034 lb ai/gal	Fruit Tree	5 gallons	0.87	0.005
			0.034 lb ai /gal	Ornamentals	5 gallons	0.87	0.005
			0.18 lb ai /1000 sq. ft	Turf	1,000 ft^2	0.92	0.005
			0.023 lb ai /gal	Vegetable/Small fruit Garden	5 gallons	0.59	0.003
			0.16 lb ai /gal	Mosquitoes (household pests)	5 gallons	3.9	0.023
Mixing/Loading/Applying Liquids with a Fogger (4)	No Data	No Data	0.012 lb ai/gal	Mosquitoes (household pests)	No Data	No Data	No Data
Mixing/Loading/Applying Dust using a Shaker Can (5)	250 (Note[1])	1063 (Note[1])	0.046lb ai/1000 sq. ft	Ornamentals	1000 ft^2	11.5	0.049
			0.10 lb ai /1000 sq. ft	Turf	1000 ft^2	25	0.110
			0.057 lb ai/1000 sq. ft	Vegetable/Small fruit Garden	1000 ft^2	14.25	0.061

Footnotes:

a Baseline dermal unit exposure represents short pants, short sleeved shirt, no gloves, and open mixing/loading. Standard Operating Procedures (SOPs) for Residential Exposure Assessments - Draft. May 1997.

b Baseline inhalation unit exposure represents no respirator. Standard Operating Procedures (SOPs) for Residential Exposure Assessments - Draft. December 1997.

c Application rates are based on maximum application rates listed on the July 1997 LUIS report and malathion homeowner labels. EPA Reg. Nos. 239-739 (50%EC), 239-568 (7.5% WP), 829-61 (5% dust)

d Crop types or targets are selected from EPA guidance.

e Amount handled per day are from EPA estimates of acres treated, gallons applied, or square feet treated.

f Daily Dermal Exposure (mg/day) = Dermal Unit Exposure (mg/lb ai) x Application Rates (lb ai/acre; lb/gal; and ai/sq ft) x Amount Handled per day (acres, gallons, sq. ft.).

g Daily Inhalation Exposure (mg/day) = Inhalation Unit Exposure (μg/lb ai) x (1 mg/1,000 μg) Conversion x Application rate (lb ai/acre; lb/gal; and ai/sq ft) x Amount Handled per day (acres, gallons, sq. ft.).

Note[1] No PHED data are available specifically for this scenario. Draft SOPs for Residential Exposure Assessment (December 1997) include unit exposure values for mixing, loading and applying a wettable powder using a low pressure handwand. These unit exposures are believed to be reasonable surrogate values for applying dust with a shaker can. Support for this assumption comes from the determination of a similar dermal unit exposure for shaker can use that appears in the published study by Kurtz and Bode (Kurtz, D.A., and Bode, W.M. 1985. Application Exposure to the Home Gardener. In Dermal Exposure Related to Pesticide Use. American Chemical Society Symposium Series 273, R.C., Honeycutt, G., Zweig, and N.N. Ragsdale Eds. American Chemical Society, Washington, D.C. Pages 139-161).

Table 14: Residential Handler Short-term Risks to Malathion at Baseline.

Exposure Scenario (Scen. #)	Crop Type or Target	Baseline Dermal Dose (mg/kg/day)[a]	Baseline Inhalation Dose (mg/kg/day)[b]	Baseline Dermal MOE[c]	Baseline Inhalation MOE[d]	Baseline Total MOE[e]
Mixer/Loader/Applicator Exposure						
Mixing/Loading/Applying Liquid with a Low Pressure Handwand (1a)	Fruit Trees	0.24	0.00007	210	350,000	210
	Ornamentals	0.24	0.00007	210	350,000	210
	Turf	0.26	0.00007	190	330,000	190
	Vegetable/Small Fruit Garden	0.16	0.00005	300	520,000	300
	Mosquitoes (household pests)	1.11	0.00033	45	78,000	45
Mixing/Loading/Applying Wettable Powder with a Low Pressure Handwand (1b)	Fruit Trees	0.18	0.00079	280	33,000	280
	Ornamentals	0.27	0.0012	190	22,000	190
	Vegetable/Small Fruit Garden	0.32	0.0014	160	18,000	150
Mixing/Loading/Applying Liquids with a Hose End Sprayer (2)	Fruit Trees	0.07	0.00002	690	110,000	690
	Ornamentals	0.07	0.00002	690	110,000	690
	Turf	0.08	0.00002	650	1,100,000	650
	Vegetable/Small Fruit Garden	0.05	0.00002	1000	1,700,000	1000
	Mosquitoes (household pests)	0.33	0.0001	150	250,000	150

Exposure Scenario (Scen. #)	Crop Type or Target	Baseline Dermal Dose (mg/kg/day)[a]	Baseline Inhalation Dose (mg/kg/day)[b]	Baseline Dermal MOE[c]	Baseline Inhalation MOE[d]	Baseline Total MOE[e]
Mixing/Loading/Applying Liquids with a Backpack Sprayer (3)	Fruit Tree	0.01	0.00007	4000	350,000	4000
	Ornamentals	0.01	0.00007	4000	350,000	4000
	Turf	0.01	0.00008	3800	330,000	3800
	Vegetable/Small Fruit Garden	0.01	0.00005	6000	520,000	5900
	Mosquitoes (household pests)	0.06	0.00034	860	75,000	850
Mixing/Loading/Applying Liquids with a Fogger (4)	Mosquitoes	Note[1]	Note[1]	Note[1]	Note[1]	Note[1]
Mixing/Loading/Applying Dust using a Shaker Can (5)	Ornamentals	0.16	0.0007	300	37,000	300
	Turf	0.36	0.002	140	17,000	140
	Vegetable/Small Fruit Garden	0.20	0.0009	250	30,000	240

Footnotes:

a Baseline Dermal Dose (mg/kg/day) = Daily Dermal Exposure (mg/day) / Body Weight (70 kg).
b Baseline Inhalation Dose (mg/kg/day) = Daily Inhalation Exposure (mg/day) / Body Weight (70 kg).
c Baseline Dermal MOE = NOEL (50 mg/kg/day) / Baseline Dermal Dose (mg/kg/day).
d Baseline Inhalation MOE = NOEL (25.8 mg/kg/day) / Baseline Inhalation Dose (mg/kg/day).
e Total MOE (short- and Intermediate-term) = 1 / ((1/Calculated Dermal MOE) + (1/Calculated Inhalation MOE)).

Note[1] No PHED data are available for this scenario. However, it is believed that the scenario for mixing/loading and applying liquid for backpack sprayer application to control mosquitos serves as a comparable, if not worst case, surrogate for the use of a small fogger unit (based on EPA Reg. No. 769-844).

Table 15: Residential Exposure Scenario Descriptions for the Use of Malathion

Exposure Scenario (Number)	Data Source	Standard Assumptions[a]	Comments[b]
Mixer/Loader/Applicator Descriptors			
Mixing/Loading/Applying Liquid with a Low Pressure Handwand (1a)	SOPs for Residential Exposure Assessments (12/97)	5 gallons for small vegetable gardens, mosquitoes (household pests), fruit trees and ornamentals; and 1,000 ft^2 for spot-treatment of turf	**Baseline**: Dermal and inhalation data = ABC grades, and hands data = All grade. Dermal = 9-80 replicates; hands = 70 replicates; and inhalation = 80 replicates. Low confidence in hands, dermal data. Medium confidence in inhalation data. **PPE and Engineering Controls**: Not feasible for assessment.
Mixing/Loading/Applying Wettable Powder with a Low Pressure Handwand (1b)	SOPs for Residential Exposure Assessments (12/97)	5 gallons for small vegetable gardens, mosquitoes (household pests), fruit trees, and ornamentals	**Baseline:** Dermal and inhalation data = C grades, and hands data = A grade. Dermal = 16 replicates; hands = 15 replicates; and inhalation = 16 replicates. Low/medium confidence in hands and dermal data. Medium confidence in inhalation data. **PPE and Engineering Controls:** Not feasible for assessment.
Mixing/Loading/Applying Liquid With a Hose-end Sprayer (2)	SOPs for Residential Exposure Assessments (12/97)	5 gallons on trees, ornamentals and small vegetable gardens; and 1,000 ft^2 for spot-treatment of turf	**Baseline**: Dermal and inhalation = C grade, and hands = E grade. Dermal, inhalation, and hands = 8 replicates each. Low confidence in all data. **PPE and Engineering Controls**: Not feasible for assessment.
Mixing/Loading/Applying Liquid Using a Backpack Sprayer (3)	SOPs for Residential Exposure Assessments (12/97)	5 gallons on fruit/nut trees, ornamentals, and small vegetable gardens; and 1,000 ft^2 for spot-treatment of turf	**Baseline**: Dermal = AB grade; inhalation = A grade; and hands = C grade. Dermal = 9 to 11 replicates; hands = 11 replicates; and inhalation = 11 replicates. Low confidence in dermal, hands, and inhalation data. A 90% protection factor was used to backcalculate "no glove" hand data from the gloved scenario. **PPE and Engineering Controls**: Not feasible for assessment.
Mixing/Loading/Applying Liquid with a Fogger (4)	See Comments	See Comments	No PHED Data. However, it is believed that the scenario for mixing/loading and applying liquid for backpack sprayer application to control mosquitos serves as a comparable, if not worst case, surrogate for the use of a small fogger unit (based on EPA Reg. No. 769-844).
Loading/Applying Dust Using a Shaker Can (5)	SOPs for Residential Exposure Assessments (12/97)	1,000 ft^2 for spot-treatment of turf, ornamentals and small vegetable gardens	No PHED Data. Unit exposure values for mixing, loading and applying wettable powders using a low pressure handwand, found in the Draft SOPs for Residential Exposure Assessment (December 1997), were used as a reasonable surrogate for shaker can exposure. This assumption is supported by published study data on shaker can usage (Kurtz and Bode, 1985).

[a] Standard Assumptions based on HED estimates.

[b] "Best Available" grades are defined by HED SOP for meeting Subdivision U Guidelines (Series 875 - Group A). Best available grades are assigned as follows: matrices with grades A and B data and a minimum of 15 replicates; if not available, then grades A, B and C data and a minimum of 15 replicates; if not available, then all data regardless of the quality and number of replicates. Data confidence are assigned as follows:

High = grades A and B and 15 or more replicates per body part
Medium = grades A, B, and C and 15 or more replicates per body part
Low = grades A, B, C, D and E or any combination of grades with less than 15 replicates

3.1.3 Summary of Risk for Non-Occupational Handlers, Data Gaps, and Confidence in Exposure and Risk Estimates

There are two toxicological endpoints for short-term and intermediate-term exposures. Risks for cholinesterase inhibition were calculated for dermal exposure and for the combined risk (Total MOE) from dermal and inhalation exposure (target MOE =100). Risk for histopathology in respiratory epithelium was calculated for inhalation exposure (target MOE =1000). A chronic risk assessment was not completed for the handlers because the use patterns do not indicate any chronic exposure patterns. Cholinesterase inhibition drives the risk from malathion exposure and, therefore, the summary of non-occupational handler risks below is for this toxicological endpoint.

Short- and Intermediate-term Residential Handler Risks

The calculations of short- and intermediate-term risks indicate that the **total MOE is equal to, or greater than 100** for the following scenarios:

- (1a) mixing/loading/applying liquid with a low pressure handwand (fruit trees, ornamentals, turf and vegetable/small fruit garden).
- (1b) mixing/loading/applying wettable powder with a low pressure handwand (fruit trees,ornamentals and vegetable/small fruit garden).
- (2) mixing/loading/applying with a hose end sprayer (fruit trees, ornamentals, turf, vegetable/small fruit garden, and mosquitoes).
- (3) mixing/loading/applying with a backpack sprayer (fruit trees, ornamentals, turf, vegetable/small fruit garden, and mosquitoes).
- (4) mixing/loading/applying liquids with a fogger (mosquitoes). This scenario was not specifically quantified, but an equivalent-to-worst case for this scenario is assumed to be represented by mixing/loading/applying liquids with a backpack sprayer (scenario 3).
- (5) mixing/loading/applying dust using a shaker can (ornamentals, turf, and vegetable/small fruit garden). This assumes that unit exposures are equivalent to that for scenario (1b).

The calculations of short- and intermediate-term risks indicate that the **total MOE is not equal to, or greater than 100** for the following scenarios:

- (1a) mixing/loading/applying liquid with a low pressure handwand (mosquitoes/ household pests).

Data Gaps. The following data gaps exist for the following scenarios:

- (4) mixing/loading/applying with a fogger (mosquitoes). Risk for this scenario is assumed to be less than or equivalent to scenario 3.
- (5) mixing/loading/applying dust using a shaker can (ornamentals, turf, and vegetable/small fruit garden). Unit exposure for this scenario is assumed to be equivalent to that for scenario (1b).

Data Quality and Confidence in Assessment. Several issues must be considered when interpreting the homeowner handler risk estimates:

- Several handler assessments were completed using “low quality” PHED data due to the lack of a more acceptable dataset.

- Several generic protection factors were used to calculate handler exposures. These protection factors have not been completely evaluated and accepted by HED.

- Factors used to calculate daily exposures to handlers (e.g., square feet treated per day and gallons of liquid applied) are based on the best professional judgement.

- PHED data were from estimates found in the *Standard Operating Procedures (SOPs) for Residential Exposure Assessments (December 1997)*.[8]

3.2 Non-occupational Postapplication Exposures and Risks

EPA has determined that there are potential post-application exposures to residents contacting treated lawns, contacting residues on turf at home and in public areas from aerial or ground public mosquito control and spray drift from agricultural applications in nearby fields, performing work in treated vegetable gardens, harvesting from fruit and nut trees, pruning or thinning ornamental trees or shrubs and harvesting strawberries in commercial "pick-your-own" fields. While other scenarios, such as exposure on golf courses are also possible, the ones chosen here are the most common exposure scenarios and the ones most likely to bracket the overall risk. Also, it should be noted that the inhalation component of post-application exposure is usually negligible in comparison to the contribution of dermal exposure, and is therefore, not included in most determinations of postapplication risk. However, because of the widespread aerial and truck-fogger application of malathion in public mosquito-vector control, a postapplication inhalation exposure scenario is discussed separately in a later section. Also, a separate evaluation of spray drift from the USDA Boll Weevil Eradication Program is presented.

3.2.1 Postapplication Exposure Scenarios, Data, and Assumptions

The scenarios likely to result in postapplication exposures are listed in Table 16 and are as follows:

- Dermal exposure from residues on vegetable/small fruit gardens;
- Dermal exposure from residues on fruit trees and ornamentals;
- Dermal exposure from "pick your own" strawberries;
- Dermal exposure from residues on residential, park and school playground sites due to aerial and ground mosquito abatement applications.(adult and toddler);
- Dermal exposure from residues on treated residential turf (adult and toddler);
- Incidental nondietary ingestion of residues on lawn (residential, park and school playground) from hand-to-mouth transfer (toddler) [note that postapplication exposures from various activities following lawn treatment are considered to be the most common and significant in residential settings. The exposure via incidental non-dietary ingestion of other plant material (e.g., vegetable/fruit garden crops) may occur but is considered negligible, and is not assessed];
- Ingestion of treated turfgrass (residential, park and school playground) (toddler); and
- Incidental ingestion of soil from treated areas (residential, park and school playground) (toddler).

Because of the unique circumstances regarding the special uses of malathion in public health mosquito abatement control and the USDA's Boll Weevil Eradication Program, the inhalation exposure from ground and aerial mosquito abatement applications (adult and toddler), as well as, dermal and inhalation exposure to residential bystanders from aerial application of malathion for the USDA Boll Weevil Eradication Program, are assessed separately in sections to follow.

3.2.2 Basis and Approach for Assessment of Postapplication Scenarios

A transferable residue study on turf (MRID 441133-01) was conducted with malathion formulated as the end use product Malathion 57EC. This study examined the residue levels of malathion that could be transferred from treated turf. A description of this study appeared earlier under section 2.2.2. In this current section on non-occupational post-application exposure, the results of that turf study are used in the similar manner as was made for occupational postapplication assessement. Postapplication risks involving contact with turf were based on an intial amount of residue available to transfer to the skin predicted by the regression analysis (i.e., 1.3% of the application rate) which included the actual TTR value measured immediately after application (0 hour) in the turf study. For activities involving contact with other crops, the HED standard default value for the amount of residue initially available to transfer to skin (i.e., 20% of the application rate) was used. Residue values estimated for 0 hours (just after sprays have dried) are assumed for residential scenarios because restricted entry intervals are not applicable in the residential setting.

HED has determined that there are potential post-application exposures to adults and children contacting residues on turf resulting from public mosquito control uses. Potential exposures are estimated because of the concern for the residues that may be deposited during the ultra low volume (ULV) aerial and ground-based fogger applications in the vicinity of residential dwellings. The assessment has been developed to ensure that the potential exposures are not underestimated and to represent a conservative model that encompasses potential exposures received in other recreational areas (e.g., school playgrounds, parks, athletic fields). The scenarios likely to result in post-application exposures are follows:

- Dermal exposure from residues deposited on turf at residential, park, and school sites (adult and toddler);
- Incidental nondietary ingestion of residues deposited on turf at residential, park, and school sites from hand-to-mouth transfer (toddler);
- Ingestion of treated turfgrass (toddler); and
- Incidental ingestion of soil from treated areas (toddler).

As mentioned earlier, bystander activity in the immediate vicinity and in the same time frame as ULV ground-based fogging or aerial ULV operations may result in inhalation exposure. While not considered to be a major contributor to the hazard, an estimate of the risk from this potential exposure is also given.

Chemical-specific data for mosquito uses have not been submitted by the registrant. Therefore, the equations and assumptions used for each of the scenarios were derived from airborne exposure models, and taken from published literature studies and the Draft Standard Operating Procedures (SOPs) for Residential Exposure Assessments guidance document. A description of the literature studies, the model and the assumptions and equations are provided below.

Ground-based ULV

In the study conducted by Moore *et al.,* [*Downwind Drift and Deposition of Malathion on Human Targets From Ground Ultra-Low Volume Mosquito Sprays*: J.C. Moore, J.C. Dukes, J.R. Clark, J. Malone, C.F. Hallmon, and P.G. Hester; Journal of the American Mosquito Control Association; Vol. 9, No. 2 (June, 1993)] both human exposure and deposition was quantified over 5 separate application events. A 91 percent formulation of malathion was applied in April and May of 1989 in the early evening

(a time of day for relative atmospheric stability). A Leco HD ULV cold aerosol generator (Lowndes Engineering Company, Valdosta Georgia) was used to make each application. The application parameters included a fluid flow rate of 4.3 fluid ounces per minute, a vehicle groundspeed of 10 mph, and a nominal application rate of 0.05 lb ai/acre (i.e., equates to a deposition rate of 0.51 $\mu g/cm^2$). Deposition was monitored at three locations downwind from the treatment area (i.e., 15.2 m, 30.4 m, and 91.2 m). For the events considered in the deposition calculations, "average amounts of malathion deposited on ground level at 15.2, 30.4, and 91.2 m were not significantly different." The percentage of the application rate reported to have deposited ranged from 1 to 14 percent. The mean deposition value for all measurements was 4.3 percent (n=35, CV=98).

In the study conducted by Tietze *et al.,* [*Mass Recovery of Malathion in Simulated Open Field Mosquito Adulticide Tests*: N.S. Tietze, P.G. Hester, and K.R. Shaffer; Archives of Environmental Contamination and Toxicology; 26: 473-477 (1994)] only deposition was quantified over 6 separate application events (i.e., one event was not included in deposition calculations "due to negative air stability"). The application parameters were similar to that used by Moore *et al*. A 95 percent formulation of malathion was applied from May to August of 1993. A Leco 1600 ULV cold aerosol generator (Lowndes Engineering Company, Valdosta Georgia) was also used to make each application. The application parameters included a fluid flow rate of 4.3 fluid ounces per minute, a vehicle groundspeed of 10 mph, and a nominal application rate of 0.057 lb ai/acre (i.e., equates to a deposition rate of 0.58 $\mu g/cm^2$). Deposition was monitored at four locations downwind from the treatment area (i.e., 5 m, 25 m, 100 m and 500 m). For the events considered in the deposition calculations, "malathion mass deposited differed significantly between the 500 m site and the three closer sites (df = 3; F-value = 3.42; P<0.05)." The percentage of the application rate reported to have deposited (not including 500 m samples which were much less) ranged up to 5.8 percent. The mean deposition value for all measurements was 3.8 percent.

After considering the data that are available in the Tietze *et al.* and Moore *et al.* papers, an off-target deposition rate of 5 percent of the application rate was used by HED to evaluate ground-based ULV applications (i.e., 5 percent of application rate is the deposition rate of which 1.3 percent is determined from the turf study discussed earlier, to be available for transferring to skin). A value slightly higher than the mean values for both studies was selected because of the variability in the data and the limited number of data points. It should be noted that this value is also consistent with the draft modeling assessment for ground-ULV approaches completed by S.T. Perry and W.B. Petersen of EPA's Office of Research and Development (i.e., within a factor of 5). Perry and Petersen used "the INPUFF Lagrangian puff model" as the basis for their assessment (Petersen and Lavdas, 1986: *INPUFF 2.0 - A Multiple Source Gaussian Puff Dispersion Algorithm, User's Guide*, EPA/600/8-86/024). Depending on the scenario selected from this document, deposition rates ranged from aproximately 2.5 percent deposition 450 m downwind to 15 to 20 percent deposition **immediately adjacent** to the treatment zone.

Aerial ULV

Data similar to that for ground applications discussed above were not available for the aerial deposition. Therefore, in order to calculate deposition from aerial ULV applications, HED used *AgDRIFT* (V 1.03 -- June 1997) which is the model that was developed as a result of the efforts of the *Spray Drift Task Force (SDTF).* The SDTF is a coalition of 38 pesticide registrants whose primary objectives were to develop a comprehensive database of off-target drift information in support of pesticide registrations and an appropriate model system. This model was selected based on the consensus of several experts in the spray drift area because it represents the current state-of-the-art. HED discussed the issue of model selection with several experts in the spray drift community prior to selecting *AgDRIFT* (e.g., Sandra L. Bird, U.S. EPA; Steven G. Perry, U.S. EPA; Milton E. Teske, Continuum Dynamics; Pat Skyler, U.S. Forest Service; Arnet Jones, U.S. EPA; and Harold Thistle, U.S. Forest Service). HED considered using the *USDA Forest Service Cramer-Barry-Grim Model* (commonly referred to as *FSCBG*). *FSCBG* was

developed through support from the U.S. Forest Service, in cooperation with the U.S. Army, and has been in existence for over 20 years in various iterations. Actual support and development of *FSCBG* was completed by Continuum Dynamics, Inc. located in Princeton, New Jersey under the technical direction of Milton E. Teske. However, it was decided that *AgDRIFT* should be used because it is based on essentially the same algorithms as *FSCBG* (personal communication with Milton E. Teske of Contiuum Dynamics), it has undergone extensive validation by the *SDTF*, and it is very user-friendly compared to *FSCBG*.

AgDRIFT is a *Microsoft Windows*-based personal computer program that is provided to the U.S. Environmental Protection Agency's Office of Pesticide Programs as a product of the Cooperative Research and Development Agreement (CRADA) between EPA's Office of Research and Development and the *SDTF*. *AgDRIFT* predicts the motion of spray material released from aircraft, including the mean position of the material and the position variance about the mean as a result of turbulent fluctuations. *AgDRIFT* enhancements include a significant solution speed increase, an in-memory computation of deposition and flux as the solution proceeds, and extensive validation based on 180 separate aerial treatments performed during field trials in 1992 and 1993 by the SDTF.

AgDRIFT is capable of producing a variety of useful outputs. The key for HED in this assessment was to determine from the model what percentage of the application volume remained aloft and what percentage of the resulting droplets deposited on the surfaces in the treatment area as well as downwind from the treatment area. *AgDRIFT* is generally intended to calculate deposition rates in areas that are downwind from the treatment area (i.e., presented from the border of the treatment area to areas of interest downwind). HED has used the values at the border of the treatment area to represent the deposition rate within the treated area.

Deposition from aerial ULV applications is assumed to be uniform throughout the drift zone even though *AgDRIFT* indicates minor fluctuations in the region of interest. The deposition region of interest has been defined as the region immediately adjacent to the treatment area out to a reasonable model approximated limit (i.e., for aerial -- about 2000 feet).

The following are important *AgDRIFT* model input parameters used for this risk assessment.

For aerial ULV mosquito control:	For aerial ULV boll weevil eradication:
Droplet size distribution	
$D_{v0.1}$ = 29.45 μm; $D_{v0.5}$ = 56 μm; $D_{v0.9}$ = 108 μm; < 141 μm: 98%	$D_{v0.1}$ = 65 μm; $D_{v0.5}$ = 110.74 μm; $D_{v0.9}$ = 179.99 μm; < 141 μm: 75.07%
Spray material	
Inputs include: nonvolatile rate = 0.24 lb per acre; specific gravity = 1.2; spray rate = 0.05 gal/acre; active ingredient application rate = 0.23 lb ai/acre; and, evaporation rate = 1 μm^2/deg C/sec).	Inputs include: nonvolatile rate = 2.5 lb per acre; specific gravity = 1.2; spray rate = 0.25 gal/acre; active ingredient application rate = 0.9 lb ai/acre; and, evaporation rate = 1 μm^2/deg C/sec).
Aircraft	
User defined option (fixed-wing aircraft). Inputs include: Douglas DC3; wingspan = 94.6 ft; typical application airspeed = 228.1 mph; weight = 21,396 lb.; planform area = 1009.63 ft^2; propeller RPM = 2550; propeller radius = 5.81 ft; engine vertical distance = -1.22 ft; and, engine forward distance = 6.1 ft;	User defined option (fixed-wing aircraft). Inputs include: Air Tractor AT-401; wingspan = 49 ft; typical application airspeed = 120 mph; weight = 6000 lb.; planform area = 294 ft^2; propeller RPM = 2000; propeller radius = 4.5 ft; engine vertical distance = -1.2 ft; and, engine forward distance = 11.9 ft;
Nozzels	

User defined option. Inputs include: number of nozzels = 60; vertical distance = -2.66 ft; forward distance = -0.8202 ft; and, horizontal distance limit = 75 %.	User defined option. Inputs include: number of nozzels = 42; vertical distance = -2.66 ft; forward distance = -0.8202 ft; and, horizontal distance limit = 0 %.
Meteorology	
Windspeed = 2 mph; wind direction = - 90 degrees (perpendicular to flight path); temperature = 86 deg F; and, relative humidity = 90%.	Windspeed = 10 mph; wind direction = - 90 degrees (perpendicular to flight path); temperature = 86 deg F; and, relative humidity = 50%.
Control	
Release height = 300 ft; number of spray lines = 20 (aircraft passes) in each application event; swath width = 499 ft; and, swath displacement based on aircraft centerline.	Release height = 10 ft; number of spray lines = 20 (aircraft passes) in each application event; swath width = 55 ft; and, swath displacement = 27.5 ft..
Advanced settings	
Wind speed height = 2 m; maximum compute time = 600 sec; maximum downwind distance 795 meters; vortex decay rate = 0.56 m/sec; propeller efficiency = 0.8; and ambient pressure = 1013 mb.	Wind speed height = 2 m; maximum compute time = 600 sec; maximum downwind distance 795 meters; vortex decay rate = 0.56 m/sec; propeller efficiency = 0.8; and ambient pressure = 1013 mb.

For aerial ULV mosquito control, it was determined that in the area of concern (i.e., from the edge of the treatment area to 1000 feet downwind), approximately 35 percent of the theoretical application is deposited. For aerial ULV boll weevil control, it was determined that in the area of concern (i.e., from the edge of the field to 75 feet downwind), approximately 40 percent of the theorectical application is deposited.

After the deposition factors were determined, post application exposure values were calculated using appropriate surrogate exposure values, label stipulated application rates, and application rates based on available use information.

Assumptions and Surrogate Data. Residential risks were assessed for both adults and toddlers based on guidance provided in the *Draft: Standard Operating Procedures (SOPs) for Residential Exposure Assessment (12/11/97 Version)*. Additionally, the open literature and the SDTF *AgDRIFT* model was used to assess deposition to residential turf after malaria vector applications of ULV liquids. These efforts were necessary to integrate the unique agricultural engineering aspects of malaria vector control applications into the HED risk assessment. Calculations for both adults and toddlers were completed using the maximum application rates for ground-based and aerial application scenarios.

No proprietary data from the Spray Drift Task Force (SDTF) was used in this assessment. Additionally, AgDRIFT was recently presented before the FIFRA Science Advisory Panel. Modifications to the model are possible as a result of the SAP comments. These modifications, however, are anticipated by HED not to significantly alter the results of this assessment. Any significant modifications to the model may require further refinement of this assessment. Even given the potential for modification of the model, the assessment is much more refined than assuming 100 percent of the application rate is deposited on the turf in residential areas where aerial ULV applications occur. The latter approach (i.e., 100% deposition) is recognized by HED as completely unrealistic given what is known concerning the engineering aspects of malaria vector control and other aerial ULV applications.

The equations and assumptions used for each of the scenarios were taken from the Draft Standard Operating Procedures (SOPs) for Residential Exposure Assessments guidance document[8]. Interim changes to these SOPs have been adopted by the HED Exposure Science Advisory Council regarding standard values for turf transferrable residues, turf transfer coefficient and hand-to-mouth activities. The

new standard values are used throughout this assessment, and are denoted below with (‡). The following general assumptions were made for all scenarios:

- Postapplication was assessed on the same day the pesticide is applied because it was assumed that the homeowner could be exposed to gardens, fruits and nuts, ornamental shrubs, flowers, trees, and turfgrass immediately after application. Therefore, postapplication exposures were based on day 0.

- Adults were assumed to weigh 70. Toddlers (3 years old), used to represent the 1 to 6 year old age group, were assumed to weigh 15 kg.

- The maximum labeled application rate (ULV) for aerial mosquito control is 0.23 lb ai/acre. The maximum labeled application rate (ULV) for ground-based fogger mosquito control is 0.11 lb ai/acre. (based on FYFANON® ULV label. EPA Reg. No. 4787-8)

- The dermal transfer coefficient which is the basis for the toddler calculation is based on a Jazzercise activity which is generally considered to represent a bounding estimate of dermal exposure. Another conservative aspect of the postapplication calculation is the duration in which exposed populations are assumed to be in contact with treated turf on a daily basis (i.e., 2 hours/day for adults and toddlers -- both upper percentile estimates based on data available in the *EPA Exposure Factors Handbook*).

Dermal exposure (turf, gardens, fruit & nuts, and ornamentals):

$$ADD = (DFR_t * CF1 * Tc * ET) / BW$$

where:

ADD = average daily dose (mg/kg/day)
DFR_t = dislodgeable foliar residue on day "t" ($\mu g/cm^2$)
CF1 = weight unit conversion factor to convert μg units in the DFR value to mg for the daily dose (0.001 mg/μg)
Tc = transfer coefficient (cm^2/hr)
ET = exposure time (hr/day)
BW = body weight (kg)

and

$$DFR_t = AR * F * (1-D)^t * CF2 * CF3$$

where:

AR = application rate (lb ai/sq feet) [* 35 percent for aerial foggers, and * 5 percent for ground-based foggers]
F = fraction of ai retained on foliage (0.013 for turf; 0.2 for all other crops, unitless)
D = fraction of residue that dissipates daily (0.72 for turf; 0.46 for other crops, unitless)
t = postapplication day on which exposure is being assessed (day 0)
CF2 = weight unit conversion factor to convert the lbs ai in the application rate to μg for the DFR value (4.54E8 μg/lb)
CF3 = area unit conversion factor to convert the surface area units (ft^2) in the application rate to cm^2 for the DFR value (2.47E-8 acre/cm^2 if the application rate is per acre)

- (‡) The mean dermal transfer coefficient for turf was assumed to be 14,500 cm^2/hr for adults and 5,200 cm^2/hr for toddlers.

- The mean dermal transfer coefficient for gardens, fruit and nuts, and ornamentals was assumed to be 10,000 cm^2/hr for adults.

- The exposure time for toddlers and adults to turf was assumed to be 2 hours per day.

- The exposure time for adults (age 18-64 years) to garden and tree foliage was assumed to be 0.67 hours per day, based on the 95th percentile values for time spent working in a garden or other circumstances working with soil.

Hand-to-mouth (turf):

$$ADD = (DFR_t * SA * FQ * EX * ET * CF1) / BW$$

where:

ADD	=	average daily dose (mg/kg/day)
DFR_t	=	dislodgeable foliar residue on day "t" ($\mu g/cm^2$ turf)
SA	=	surface area of the hands (cm^2/event)
FQ	=	frequency of hand-to-mouth activity (events/hr)
ET	=	exposure time (hr/day)
EX	=	extraction by saliva
CF1	=	weight unit conversion factor to convert μg units in the DFR value to mg for the daily exposure (0.001 mg/μg)
BW	=	body weight (kg)

- (‡) The median surface area of both hands was assumed to be 20 cm^2 for a toddler (age 3 years).

- Replenishment of the hands with pesticide residues was assumed to be an implicit factor in this assessment.

- (‡) It was assumed that 5% of the application rate is initially available to transfer to the hands. This includes concerns for sticky hands.

- (‡) It was assumed that 50% of the residue on the hand is extracted by saliva.

- (‡) The mean rate of hand-to-mouth activity is 20 events/hr for toddlers (3 to 5 years old).

- The duration of exposure for toddlers was assumed to be 2 hours per day for turf and 0.33 hours for the garden.

Turfgrass ingestion:

$$ADD = (GR_t * IgR * CF1) / BW$$

where:

ADD	=	average daily dose (mg/kg/day)
GR_t	=	grass residue on day "t" ($\mu g/cm^2$)
IgR	=	ingestion rate of grass (cm^2/day)
CF1	=	weight unit conversion factor to convert the μg of residues on the grass to mg to provide units of mg/day (1E-3 mg/μg)
BW	=	body weight (kg)

and

$$GR_t = AR * F * (1-D)^t * CF2 * CF3$$

where:

AR = application rate (lb ai/acre) [* 35 percent for aerial foggers, and * 5 percent for ground-based foggers]
F = fraction of ai available on the grass (unitless)
D = fraction of residue that dissipates daily (unitless)
t = postapplication day on which exposure is being assessed
CF2 = weight unit conversion factor to convert the lbs ai in the application rate to μg for the grass residue value (4.54E8 μg/lb)
CF3 = area unit conversion factor to convert the surface area units (ft^2) in the application rate to cm^2 for the grass residue value (2.47E-8 acre/cm^2 if the application rate is per acre)

- The assumed ingestion rate for grass for toddlers (age 3 years) was 25 cm^2/day (i.e., 2 x 2 inches or 4 in^2). This value was intended to represent the approximate area from which a child may grasp a handful of grass.

Incidental Soil Ingestion (turf):

$$ADD = (SR_t * IgR * CF1) / BW$$

where:

ADD = average daily dose (mg/kg/day)
SR_t = soil residue on day "t" (μg/g)
IgR = ingestion rate of soil (mg/day)
CF1 = weight unit conversion factor to convert the μg of residues on the soil to grams to provide units of mg/day (1E-6 g/μg)
BW = body weight (kg)

and

$$SR_t = AR * F * (1-D)^t * CF2 * CF3 * CF4$$

where:

AR = application rate (lb ai/acre) [* 35 percent for aerial foggers, and * 5 percent for ground-based foggers]
F = fraction of ai available in uppermost cm of soil (fraction/cm)
D = fraction of residue that dissipates daily (unitless)
t = postapplication day on which exposure is being assessed
CF2 = weight unit conversion factor to convert the lbs ai in the application rate to μg for the soil residue value (4.54E8 μg/lb)
CF3 = area unit conversion factor to convert the surface area units (ft^2) in the application rate to cm^2 for the SR value (2.47E-8 acre/cm^2 if the application rate is per acre)
CF4 = volume to weight unit conversion factor to convert the volume units (cm^3) to weight units for the SR value (0.67 cm^3/g soil)[7]

- On the day of application, it was assumed that 100 percent of the application rate are located within the soil's uppermost 1 cm.

- The assumed soil ingestion rate for children (ages 1-6 years) was assumed to be 100 mg/day.

Risk Calculations

Intermediate-term MOEs were calculated as follows, using the NOAELs for malathion, as described previously:

$$MOE = \frac{NOEL}{ADD}$$

3.2.3 Inhalation Exposure and Risk from Aerial ULV and Ground-based Truck Fogger Application for Mosquito Control

As mentioned earlier, inhalation exposure usually does not factor significantly into postapplication risk. However, due to the major use of malathion in ULV aerial and truck fogger applications to control mosquitoes, a risk assessment has been developed below for residential inhalation exposure from aerial ULV and ground-based truck fogger applications. The approach is based on the one described in the Draft Standard Operating Procedures (SOPs) for Residential Exposure Assessment for inhalation exposure to outdoor residential short-term pest control. The major difference is that the SOPs begin assuming the use of a commercial fogger product that has a known volume. In the scenario below, the beginning assumption is that the full application rates for aerial ULV and ground-based fogger truck (with the standard SOP value for dilution) is available in the breathing zone of the residential bystander, thus turning an application rate expressed as lbs. ai/ft^2, into a concentration expressed in a per cubic foot (ft^3) basis. The following is a stepwise process, including assumptions and calculations for estimating residential bystander inhalation exposure to aerial ULV and truck fogger applications in mosquito control.

Data and Assumptions

- Aerial ULV application rate is 0.23 lb ai/acre
- Ground-based ULV truck fogger application rate is 0.11 lb ai/acre
- Dilution of airborne concentration of 1 to 100 (i.e., 1 percent (0.01) of product released is available for exposure
- Adult breathing rate = 0.55 m^3/hour, and weight is 70 kg; toddler breathing rate = 0.36 m^3/hour, and weight is 15 kg
- Exposure time is 20 minutes (0.33 hours)
- Target MOE = 1000
- Short- and intermediate-term Inhalation NOAEL = 25.8 mg/kg/day

Calculations

for Aerial ULV:

- Application rate of 0.23 lb ai/acre x 1 acre/43,560 ft^2 = 0.0000053 lbs ai/ft^2
- Expressed as an airborne concentration = 0.0000053 lbs ai/ft^3
  0.0000053 lbs ai/ft^3 x 35.3 ft^3/1 m^3 = 0.00019 lbs ai/m^3
  0.00019 lbs ai/m^3 x 454,000 mg/lb = 86.26 mg/m^3
- Application concentration (86.26 mg/m^3) x dilution factor (0.01) = 0.86 mg/m^3
- $Dose_{adult}$ = (concentration) x ($breathing\ rate_{adult}$) x (exposure duration) ÷ BW_{adult}
  = (0.86 mg/m^3) x (0.55 m^3/hour) x (0.33 hours/day) ÷ 70 kg = 0.002 mg/kg/day

- **Short- and Intermediate-term $Risk_{adult}$ = MOE = $NOAEL_{inhal}$./$Dose_{adult}$ = (25.8 mg/kg/day)/(0.002 mg/kg/day) = 12,900**

- $Dose_{toddler}$ = (concentration) x (breathing $rate_{toddler}$) x (exposure duration) ÷ $BW_{toddler}$ = (0.86 mg/m^3) x (0.36 m^3/hour) x (0.33 hours/day) ÷ 15 kg = 0.0068 mg/kg/day

- **Short- and Intermediate-term $Risk_{toddler}$ = MOE = (25.8 mg/kg/day)/(0.0068 mg/kg/day) = 3800**

Both adult and toddler risk estimates for inhalation exposure do not exceed the level for Agency concern for residential bystander inhalation exposure from aerial ULV mosquito control applications. It is important to note also that the above risks are based on conservative assumptions regarding the circumstances of exposure (i.e., standing for 20 minutes in an air concentration that is not considered to dissipate and for which ground deposition estimates of only 35% of the application rate have not been factored in). These inhalation exposures are aggregated with dermal risks from the same exposure scenario in a later section.

for ULV Truck-fogger

- Application rate of 0.11 lb ai/acre x 1 acre/43,560 ft^2 = 0.0000025 lbs ai/ft^2
- Expressed as an airborne concentration = 0.0000025 lbs ai/ft^3
  0.0000025 lbs ai/ft^3 x 35.3 ft^3/1 m^3 = 0.000088 lbs ai/m^3
  0.000088 lbs ai/m^3 x 454,000 mg/lb = 39.95 mg/m^3
- Application concentration (39.95 mg/m^3) x dilution factor (0.01) = 0.4 mg/m^3
- $Dose_{adult}$ = (concentration) x (breathing $rate_{adult}$) x (exposure duration) ÷ BW_{adult} = (0.4 mg/m^3) x (0.55 m^3/hour) x (0.33 hours/day) ÷ 70 kg = 0.001 mg/kg/day

- **Short- and Intermediate-term $Risk_{adult}$ = MOE = $NOAEL_{inhal}$./$Dose_{adult}$ = (25.8 mg/kg/day)/(0.001 mg/kg/day) = 25,800**

- $Dose_{toddler}$ = (concentration) x (breathing $rate_{toddler}$) x (exposure duration) ÷ $BW_{toddler}$ = (0.4 mg/m^3) x (0.36 m^3/hour) x (0.33 hours/day) ÷ 15 kg = 0.003 mg/kg/day

- **Short- and Intermediate-term $Risk_{toddler}$ = MOE = (25.8 mg/kg/day)/(0.003 mg/kg/day) = 8600**

Both adult and toddler risk estimates for inhalation exposure do not exceed the level for Agency concern for inhalation exposure to truck foggers. It is important to note also that the above risks are based on conservative assumptions regarding the circumstances of exposure (i.e., standing for 20 minutes in the direct off-loading of a fogger truck as it passes by, without consideration of dissipation or depostion rate estimates). These inhalation risks are aggregated with dermal risks from the same exposure scenario in a later section.

3.2.4 Non-Occupational Postapplication Exposure Risk Estimates

The results of the residential postapplication exposure/risk assessment are presented in Table 16.

Table 16: Short- and Intermediate-Term Residential Post-application Scenarios and Estimated Risks for Malathion

Scenario	Crop or Target	Receptor	Application Rate Per Treatment (AR) (lbs ai/sq ft)[a]	DFR (ug/cm^2)[b]	Grt (ug/cm^2)[c]	Srt (ug/g)[d]	Transfer Coefficient (Tc) (cm^2/hr)	Exposure Time (ET) (hrs/day)	Dermal Abs. (%)	Surface Area (SA) (cm^2/ event)	Freq. (FQ) (events/ hr)	IgR (cm^2/day) or (mg/day)[e]	BW (kg)	ADD (mg/kg/day)[f]	MOE[g]
Dermal exposure	Turf (handgun - by commercial applicator)	Adult	0.00019	1.2	-	-	14,500	2	100	-	-	-	70	0.50	100
		Toddler					5,200						15	0.83	60
	Turf (handgun - by residential applicator)	Adult	0.00018	1.1	-	-	14,500	2	100	-	-	-	70	0.47	110
		Toddler					5,200						15	0.79	63
	Turf (air ULV)	Adult	0.0000053	0.012	-	-	14,500	2	100	-	-	-	70	0.005	10000
		Toddler					5,200						15	0.01	5000
	Turf (grnd ULV)	Adult	0.0000025	0.0008	-	-	14,500	2	100	-	-	-	70	0.00033	150000
		Toddler					5,200						15	0.00055	90000
	Vegetable/Small Fruit Gardens	Adult	0.0000115	1.1	-	-	10,000	0.67	100	-	-	-	70	0.11	450
	"Pick-your-own" strawberries	Adult	0.0000115	1.1			10,000	1	100				70	0.16	300
	Fruit Trees & Ornamentals	Adult	0.000017	1.7	-	-	10,000	0.67	100	-	-	-	70	0.17	300
Hand-to-Mouth	Turf (handgun)	Toddler	0.00019	4.7	-	-	-	2	50 extraction	20	20	-	15	0.125	400
	Turf (air ULV)		0.0000053	0.129										0.0034	15000
	Turf (grnd ULV)		0.0000025	0.062										0.0017	29000
Turfgrass ingestion	Turf (handgun)	Toddler	0.00019	-	1.2	-	-	-	-	-	-	25	15	0.002	25000
	Turf (air ULV)		0.0000053		0.012									2.0E-5	2.5E+6
	Turf (grnd ULV)		0.0000025		0.0008									1.3E-6	3.8E+7
Incidental soil ingestion	Turf (handgun)	Toddler	0.00019	-	-	62	-	-	-	-	-	100	15	0.0004	130000
	Turf (air ULV)		0.0000053			0.6								4.0E-6	1.3E+7
	Turf (grnd ULV)		0.0000025			0.04								3.0E-7	1.7E+8

a Application rates are estimated as follows: turf(handgun) - 0.18 lb ai per 1,000 sq. ft.; turf (air ULV) - (0.23 lb ai/A)/43,560 sq. ft. per A; turf (ground ULV) - (0.11 lb ai/A)/43,560 sq. ft. per A; vegetable/small fruit gardens- (0.023 lb ai/gal * 5 gallons)/10,000 ft^2; fruit trees and ornamentals-(0.034 lb ai/gal * 5 gal)/10,000 ft^2.

b Dislodgeable foliar residue (ug/cm^2) = [AR (lbs ai/ft ^{2}) * fraction ai retained on foliage (1.3% for turf and 20% for other crop sites [* 0.35 for air ULV, or * 0.05 for ground ULV]) * 4.54E+8 ug/lb * 1.08E-3 ft^2/cm^2].

c Grass residue (ug/cm^2) = [AR (lbs ai/ft ^{2}) * fraction ai retained on foliage (1.3% [* 0.35 for air ULV, or * 0.05 for ground ULV]) * 4.54E+8 ug/lb * 1.08E-3 ft^2/cm^2].

d Soil residue (ug/cm^2) = [AR (lbs ai/ft ^{2}) [* 0.35 for air ULV, or * 0.05 for ground ULV] * 4.54E+8 ug/lb * 1.08E-3 ft^2/cm^2 * 0.67 cm^3/g soil].

e Ingestion rate: cm^2/day for grass ingestion, and mg/day for incidental soil ingestion.

f Average daily dose (ADD) (mg/kg/day)

Dermal exposure:	= [DFR (ug/cm^2) * Tc (cm^2/hr) * mg/1,000 ug * ET (hrs/day) * absorption factor (1.0)] / [BW (kg)];
Hand-to-mouth:	= [DFR (ug/cm^2) * SA (cm^2/event) * FQ (events/hr) * mg/1,000 ug * Saliva extraction (50%) * ET (hrs/day)] / [BW (kg)];
Turfgrass ingestion:	= [GRt (ug/cm^2) * IgR (cm^2/day) * mg/1,000 ug] / [BW (kg)]; and
Incidental soil ingestion:	= [SRt (ug/g) * IgR (mg/day) * g/1,000,000 ug] / [BW (kg)].

g MOE = NOAEL (50 mg/kg/day) / ADD.

3.2.5 Summary of Non-occupational Postapplication Risks, Data Gaps, and Confidence in Exposure and Risk Estimates

The surrogate assessment was based on the turf study discussed under section 2.2.4 above. Transfer coefficients used are believed to be the best currently available for the assessment of malathion postapplication exposure potential.

Postapplication Risk Estimates

The resulting surrogate residential postapplication assessment indicates that the following scenarios do not reach the target MOE (i.e., the MOEs are < 100) for short- and intermediate-term exposures from reentry:

- Dermal exposure to residues on turf following application with handgun sprayer by commercial and residential applicators (toddler);

All other scenarios exceed the target MOE.

3.3 Non-occupational Aggregate Exposures and Risks

Under the Food Quality Protection Act (FQPA), various exposure scenarios that could result in multiple non-occupational exposures to a particular pesticide must be aggregated. For pesticide uses that could result in non-occupational exposures, a realistic exposure assessment under this FQPA requirement would aggregate exposure only from activities that would reasonably be expected to occur on the same day. The assessment is done separately for adults and toddlers. For adults, aggregate exposure must consider the potential for both handling/applying the pesticide, as well as, the potential postapplication contact. For toddlers, only postapplication is relevant, however, certain age specific differences, like hand-to-mouth activity and body weight must be considered here, as well.

Aggregate assessment for malathion is addressed in a another section of the RED document, where contributions from food and drinking water are also incorporated. However, because of the unique postapplication inhalation exposure, the combined dermal and inhalation exposures for adults and toddlers following aerial ULV and ground ULV Public Health mosquito control treatment have been calculated, and appear below in Table 17.

Table 17: Non-occupational Combined Postapplication Inhalation and Dermal Risk

Scenario	Application Rate	Crop Type or Target	Dermal Daily Dose (mg/kg/day)	Dermal MOE	Inhalation Daily Dose (mg/kg/day)	Inhal. MOE	Total MOE
Adult							
(1) Postapplication Inhalation and Dermal Contact with Turf Following **Ground ULV** Truck Fogger Application	0.0000025 (lb ai/sq ft)	Public Mosquito Control	0.00033	150,000	0.001	26,000	22,000
(2) Postapplication Inhalation and Dermal Contact with Turf Following **Aerial ULV** Application.	0.0000053 (lb ai/sq ft)	Public Mosquito Control	0.005	10,000	0.002	13,000	5600
Toddler							
(1) Postapplication Inhalation and Dermal Contact with Turf Following **Ground ULV** Application	0.0000025 (lb ai/sq ft)	Public Mosquito Control	0.00055	90,000	0.003	8600	7700
(2) Postapplication Inhalation and Dermal Contact with Turf Following **Aerial ULV** Application	0.0000053 (lb ai/sq ft)	Public Mosquito Control	0.01	5000	0.0068	3800	2200

The total MOEs for combined postapplication dermal and inhalation exposures are all ≥ the target MOE of 100, and therefore do not trigger HED concern for ground or aerial ULV public health mosquito control applications.

3.4 Special Assessment for the USDA Boll Weevil Eradication Program

3.4.1 Executive Summary

The Boll Weevil Eradication Program (BWEP) is a special project under the direction of the United States Department of Agriculture. This program is unique in that it attempts to systematically eradicate the boll weevil pest in cotton-growing regions of the US. This comprehensive and systematic approach was considered to be sufficiently different from normal agricultural use of malathion on cotton, specifically, or in agriculture, in general, that it was decided to address the exposure and risk from the BWEP, separately in the sections to follow.

For the USDA Boll Weevil Eradication Program, malathion is applied to cotton using ultra low volume (ULV) techniques (95% ai), at a maximum rate of 0.9 lb active ingredient per acre, primarily by fixed-wing aircraft. Exposure to malathion from boll weevil treatment may occur to occupational handlers, to post-application workers who enter treated fields, and to non-occupational bystanders (represented primarily by individuals living in close proximity to treated fields). Risks to the above individuals were estimated by comparing potential exposures against appropriate toxicity endpoints for the routes and durations of exposure anticipated. HED concern for an individual's risk is not triggered if: (1) the dermal MOE is $\geq$ 100;(2) the inhalation MOE is $\geq$ 1000; and (3) the total MOE for dermal and inhalation exposure is $\geq$100. The findings are summarized below.

Occupational handler exposures do not trigger HED concern if certain mitigation measures are employed:

- Mixers/loaders: Total MOE = 130 with gloves only;
- Applicators: Total MOE = 610 with closed cockpit aircraft;
- Flaggers: Total MOE = 370 with baseline clothing;

Occupational postapplication exposures do not trigger HED concern at the Worker Protection Standard Restricted Entry Interval (REI) of 12 hours for low contact postapplication activities (e.g., scouting, weeding, irrigation). Occupational high contact postapplication activities (e.g., hand harvesting, or bundling and trampling picked cotton) do not reach the target MOE until one day following malathion treatment.

Non-occupational (bystander) exposures do not trigger HED concern:

- Dermal exposure from contact with residues from aerial spray drift: adult MOE = 2300; toddler MOE = 1400;
- Incidental ingestion from hand-to-mouth activity (turf): toddler MOE = 4500;
- Incidental ingestion from eating turfgrass: toddler MOE = 600,000;
- Incidental ingestion from eating soil: toddler MOE = 3.0E+6;
- Inhalation exposure: adult MOE = 7600; toddler MOE = 2600;
- Combined dermal exposure from contact with residues from aerial spray drift and inhalation: adult total MOE = 1800; toddler total MOE = 900;

Monitoring data collected by the USDA Animal and Plant Health Inspection Service (APHIS) also show levels of exposure to be relatively low in sites adjacent to spraying in accordance with the USDA Boll Weevil Eradication Program. For example, in the USDA Environmental Monitoring Report - 1995 Southeast Boll Weevil Eradication Program, all personal breathing zone samples were < 0.001 mg/m^3 . This, when compared to the air concentration predicted by the HED assessment (1.32 mg/m^3) indicates that the HED assessment includes assumptions that lead to estimates of exposure that are higher than are being found in some actual boll weevil treatment sites.

3.4.2 Exposure Assessment

3.4.2.1 Use Pattern[9]

The boll weevil eradication program utilizes malathion fomulated as a 95% ultra low volume (ULV) concentrate, applied primarily by fixed-wing aircraft (98%), with the remaining acres treated by high-cycle ground equipment, mist blowers, and helicopters. Label application rates range from 0.3 to 1.5 lb ai/acre[10]. Typical application rates are reported to be 10 to 12 fluid onces per acre (or 0.7 to 0.9 lb ai/A using Fyfanon® ULV[10]). Malathion applications begin at the pinhead square crop phenology and end at the defoliation stage, or if a killing freeze occurs. Typical length of the program is four years. The number of applications is 6-10 in the first year; 4-6 in the second year; 1-2 in the third year; and minimal in the fourth year. Application are made at intervals of 7 - 10 days.

3.4.2.2 Non-Dietary Exposure

Occupational and non-occupational (residential) exposure to malathion and malaoxon residues via dermal and inhalation routes can occur during handling, mixing, loading, and applying activities. Postapplication exposure potentials also exist. There is potential dermal exposure to persons entering treated sites (occupational and non-occupational) following application of malathion-containing products. This includes the potential for dermal and inhalation exposure to individuals (bystanders) at home or in public areas following nearby aerial applications for boll weevil eradication.

Based on toxicological criteria and potential for exposure, HED has conducted dermal and inhalation exposure assessments for the occupational handler and postapplication dermal exposure assessments for occupational workers. HED has also conducted dermal and inhalation exposure assessments for residential settings, including postapplication dermal and inadvertent oral ingestion exposure to adults and/or children from potential spray drift during cotton treatment for boll weevil eradication.

3.4.2.3 Occupational Handler Exposure Scenarios

HED has identified 3 major scenarios that account for most of the exposure potential for occupational handlers using malathion to control the boll weevil: (1) mixing/loading ULV liquids for aerial application; (2) applying ULV sprays with a fixed-wing aircraft, and; (3) flagging for ULV aerial spray application. The scenarios were classified as being short- and intermediate-term in duration (covering one day to several months). A long term exposure duration (i.e., continuous exposure of $\geq$180 days) is not expected because malathion use for boll weevil treatment is only during the cotton seasonal growth cycle.

Because application to control the boll weevil is predominantly accomplished by fixed-wing aircraft (approximately 98%), only handler scenarios involving this equipment are assessed in this document.

The estimated exposures considered for this assessment were baseline protection (long pants and a long-sleeved shirt, no gloves, and open mixing/loading), and additional personal protective equipment (PPE, which includes a double layer of clothing and gloves and/or a dust/mist respirator), or engineering controls (closed mixing/loading systems for liquids and enclosed cabs/cockpits), where needed to achieve the target Margins of Exposure (MOEs).

3.4.2.4 Occupational Handler Exposure Data Sources and Assumptions

Chemical specific data for assessing human exposures during pesticide handling activities were not submitted to the Agency in support of the reregistration of malathion. Therefore, data from the HED Pesticide Handlers Exposure Database (PHED) Version 1.1 was used.

The following assumptions and factors were used to complete this exposure assessment:

- Average body weight of an adult handler is 70 kg. This body weight is used in both the short- and intermediate-term assessment, since the endpoint of concern is not sex-specific (i.e., the cholinesterase inhibition could be assumed to occur in males or females).

- Average work day interval represents an 8 hour workday (e.g., the acres treated or volume of spray solution prepared in a typical day).

- Daily acres and volumes (as appropriate) to be treated in each scenario include:

    -- 1200 acres of cotton per day for ULV aerial applications

- Calculations are completed for the maximum (0.9 lb ai/A) from the range of application rates for the boll weevil eradication program, as identified by the U.S. Department of Agriculture (USDA)[9].

- The maximum number of days that an individual may apply malathion in years one and two of the program is approximately 70 days in a period of six months[9].

- When scenario-specific data are not available, HED calculates unit exposure values using generic protection factors that are applied to represent the use of personal protective equipment (PPE) and engineering controls.

3.4.2.5 Occupational Handler Risk Characterization

This assessment of the BWEP uses the same toxicity endpoints , approach and equations that were used earlier to assess other agricultural uses of malathion. Refer to those sections for details.

A detailed summary of the short-term and intermediate-term risk estimates for baseline, additional PPE, and engineering controls is presented in Table 18.

Table 18: Occupational Handler Short-term and Intermediate-term Risks from Malathion at Baseline, with Additional PPE, and with Engineering Controls.

Exposure Scenario (Scenario #)	Crop Type or Target	Baseline			Personal Protective Equipment (PPE)[a]			Engineering Controls		
		Dermal MOE[b]	Inhalation MOE[c]	Total MOE [d]	Dermal MOE[b]	Inhalation MOE[c]	Total MOE [d]	Dermal MOE[b]	Inhalation MOE[c]	Total MOE [d]
Mixer/Loader Exposure										
Mixing/Loading ULV Liquids for Aerial Application (1)	cotton	140 (GO)	1400	130	NA	NA	NA	NA	NA	NA
Applicator Exposure										
Applying ULV Sprays with a Fixed-Wing Aircraft (2)	cotton	See Engineering controls						630	26,000	610
Flagger Exposure										
Flagging for ULV Aerial Spray Applications (3)	cotton	400	5200	370	NA	NA	NA	NA	NA	NA

Footnotes:

[a] Personal Protective Equipment: Except where noted [GO = Gloves Only; NR = No Respirator], additional PPE means double layer of clothing, chemical resistant gloves, and dust/mist respirator.

[b] Dermal MOE (short- and intermediate-term) = NOAEL (50 mg/kg/day)/Daily Dermal Dose (mg/kg/day).

[c] Inhalation MOE(short- and intermediate-term) = LOAEL (25.8 mg/kg/day)/ Daily Inhalation Dose (mg/kg/day).

[d] Total MOE (short- and Intermediate-term) = 1 / ((1/Calculated Dermal MOE) + (1 /Calculated Inhalation MOE)).

The **baseline** calculations indicate that the total MOEs are greater than, or equal to 100 and are **NOT** of risk concern for the following scenarios:

- (1)m ixing/loading ULV liquids for aerial application (Total MOE = 130, with gloves only)
- (3) flagging for aerial ULV applications (Total MOE = 370)

The **personal protective equipment (PPE)** calculations for the scenarios requiring additional exposure reduction were not needed. PPE means double layer of clothing, chemical resistant gloves, and dust/mist respirator. Please note however, that **gloves are required above with baseline protection for the mixer/loader of ULV liquids for aerial application**.

The **engineering control** calculations for scenarios requiring additional exposure reduction, indicate that the total MOEs are greater than, or equal to 100 with additional **engineering controls** for the following scenario:

- (2) applying ULV sprays with a fixed-wing aircraft (MOE = 610)

3.4.2.6 Occupational Postapplication Exposures and Risks

EPA has determined that there are potential intermediate-term occupational postapplication exposures to individuals entering treated fields and contacting malathion and malaoxon residues on plant surfaces. Only postapplication dermal exposure has been assessed because postapplication inhalation exposure is expected to be negligible. Workers are expected, generally, to be performing activities in malathion-treated fields for at least seven or more consecutive workdays in a growing season, with some fields receiving repeat malathion applications at 7-10 day intervals. Because of the seasonal nature of malathion use, a long-term exposure scenario is not expected for field workers.

3.4.2.7 Postapplication Exposure Scenarios

The scenarios likely to result in postapplication exposure are as follows:

- Activities that have potential for a low degree of dermal contact (i.e., scouting, weeding and irrigation) Tc = 100 cm^2/hour from MRID#: 426891

- Activities that have potential for a high degree of dermal contact (i.e., hand harvesting and transferring cotton from harvester into bulk container and stomping) Tc = 2500 cm^2/hour from ARF021

Current labels include a 12 hour restricted entry interval (REI).

3.4.2.8 Data Sources and Assumptions for Postapplication Exposure

The postapplication exposure assessment for the BWEP used the same data (i.e., data from a turf transferable residue study - MRID 44113301), approach and equations as were used in the assessments for other agricultural uses of malathion. Refer to these previous sections for details.

3.4.2.9 Postapplication Occupational Risk Characterization

Postapplication Risk Estimates: Low contact postapplication activities resulted in MOEs > 100 on the same day as treatment. High contact postapplication activities resulted in MOEs $\geq$ on the 1st day following malathion treatment, and therefore, trigger HED's concern for the current 12-hour interim REI established under the Worker Protection Standard.

A summary of the postapplication worker risks appears in Table 19. The estimates were made using the following assumptions:

- Assumed percent DFR following initial treatment is 20%
- Predicted percent dissipation per day is 46%
- Hours worked per day is 8
- Transfer coefficient for low contact activities is 100; for high contact activities, Tc = 2500
- Dermal NOAEL = 50 mg/kg/day

Table 19. Summary of Malathion Occupational Post-Application Exposure and Risk Estimates				
Crops	Application Rate (lb ai/acre)	REI where MOE ≥ 100 (MOE value)		Current REI[2]
		Low contact[1]	High contact[1]	
Cotton	0.9	day 0 (2200)	day 0 (87)	12 hours
		day 1 (4000)	day 1 (160)	

1 Default transfer coefficients were used for the above categories according to HED Science Advisory Council Policy.003 (May 7, 1998).
* Low contact activities include scouting, weeding and irrigation (Tc= 100)
* High contact activities include hand harvesting (Tc= 2500) It is important to note that for cotton, which is mechanically harvested, negligible exposure is considered likely, except for any ancillary manual activities associated with the process. These latter activities , such as collecting cotton from the harvester and stomping in bulk container, must be considered in the exposure assessment, and are given the same Tc as for hand harvesting..

2 Set as interim REIs based on the criteria of the Agency's Worker Protection Standard.

3.4.3 Residential Handler Exposure

Malathion is a common home/garden use product. Residential handler exposure to malathion residues via dermal and inhalation routes can occur during handling, mixing, loading, and applying activities. Assessment of these exposures is covered in earlier sections of this document.

3.4.3.1 Residential Postapplication Exposures and Risks

HED has determined that there is potential for non-occupational postapplication exposures to malathion residues from spray drift from the use of malathion on cotton in the USDA Boll Weevil Eradication Program.

This assessment considers the potential for inhalation (adults and children), dermal contact with residues on residential turf (adults and children), and incidental oral ingestion (children only) of malathion residues on residential turf and soil, following application of nearby cotton fields with malathion.

These potential exposures are estimated because of the concern for the residues that may be deposited during the ultra low volume (ULV) aerial applications in the vicinity of residential dwellings. The assessment has been developed to ensure that the potential exposures are not underestimated and to represent a conservative model that encompasses potential exposures received in other recreational areas (e.g., school playgrounds, parks, athletic fields).

HED believes it is reasonable to expect dermal, inhalation, and inadvertent oral exposure from this application to occur in a single day. The risks for both short- and intermediate-term toxicity have been assessed.

3.4.3.2 Postapplication Exposure Scenarios

The scenarios likely to result in dermal and inhalation(adult and child), and incidental non-dietary (child) postapplication exposures resulting from boll weevil control uses are as follows:

- Dermal exposure from residues deposited on turf at residential, park, and school sites (adult and toddler);
- Incidental nondietary ingestion of residues deposited on turf at residential, park, and school sites from hand-to-mouth transfer (toddler);
- Ingestion of treated turfgrass (toddler); and
- Incidental ingestion of soil from treated areas (toddler).
- Inhalation from airborne spray drift;

3.4.3.3 Data Sources and Assumptions for Residential Postapplication Exposure

Residential exposures were assessed for both adults and toddlers based on guidance provided in the *Draft: Standard Operating Procedures (SOPs) for Residential Exposure Assessment (12/11/97 Version)*. Additionally, foliar dissipation data submitted in support of reregistration and modeled estimates of deposition using *AgDRIFT* (V. 1.03 -- June 1997 developed by the *Spray Drift Task Force (SDTF))* were utilized to generate postapplication exposure estimates. Human exposure and deposition monitoring data from published USDA sources were summarized to further characterize the risk.. Refer to previous sections on Data Sources and Assumptions for Residential Postapplication Exposure for more details.

The equations and assumptions used for each of the scenarios were taken primarily from the Draft Standard Operating Procedures (SOPs) for Residential Exposure Assessments guidance document. Chemical-specific data for the use of malathion in the boll weevil eradication program are available from the USDA. These data are discussed in a later section and serve to further characterize the risk determined by the use of models below.

Airborne Exposure Models - Aerial ULV

In order to calculate deposition from aerial ULV applications, HED used *AgDRIFT* (V 1.03 -- June 1997). AgDRIFT is capable of producing a variety of useful outputs. The key for HED in this assessment was to determine from the model what percentage of the application volume remained aloft and what percentage of the resulting droplets deposited on the surfaces in the treatment area as well as downwind from the treatment area. It was determined that from the edge of the treatment area to 75 feet downwind, approximately **40 percent of the theoretical application is deposited**. Thus, the amount of residue on turf resulting from aerial ULV application and available for dermal transfer is estimated as follows:

amount available for transfer = amount deposited x amount transferrable (1.3%, except for hand-to-mouth activities: where 5% is used to account for concerns for sticky hands), where
amount deposited = application rate x deposition rate (40%).

After the deposition factors were determined, postapplication exposure values were calculated using appropriate surrogate exposure values, and application rate based on available use information.

The following additional general assumptions were made for all scenarios:

- Dermal exposure to residues on turfgrass following treatment of nearby cotton fields is considered to be the worst-case scenario for use in assessing residential dermal postapplication risk from the Boll Weevil Eradication Program.

- Postapplication was assessed on the same day the pesticide is applied because it was assumed that the homeowner could be exposed to turfgrass immediately after application. Therefore, postapplication exposures were based on the day of application (i.e., day 0).

- Adults were assumed to weigh 70 kg. Toddlers (3 years old), used to represent the 1 to 6 year old age group, were assumed to weigh 15 kg.

- The maximum application rate (ULV) for aerial boll weevil control is 0.9 lb ai/acre.

- The transfer coefficient which is the basis for the dermal calculation is based on a Jazzercise activity which is generally considered to represent a bounding estimate of dermal exposure. Another conservative aspect of the postapplication calculation is the duration in which exposed populations are assumed to be in contact with treated turf on a daily basis (i.e., 2 hours/day for adults and toddlers).

Additional parameters that effect residue transfers from surface-to-skin, skin-to-mouth, and object-to-mouth activities for adults and/or children are as follows:

Surface-to-skin residue transfer (adult and toddler)
Residue source: turf exposure time = 2 hours per day; TC = 14,500 cm2/hr (adult) and 5,200 cm2/hr (toddler)

Skin-to-mouth residue transfer (toddler)
residue source: plant surface residue transfer to the hand and to the mouth
The palmar surface area of 3 fingers was assumed to be 20 cm2 for a toddler (age 3 years); replenishment of the hand with pesticide residues was assumed to be an implicit factor; it was assumed that there is a 50% extraction by saliva.
The initial amount of residue available to transfer to the hands is assumed to be 5% of the amount deposited to account for concerns for sticky hands.

residue source: soil particles transfer from the hand to the mouth
On the day of application, it was assumed that 100% of the application rate is available in the uppermost 1 cm of soil; the assumed ingestion rate for children ages 1-6 is 100 mg/day

Object-to-mouth residue transfer (toddler)
residue source: grass surface
The assumed ingestion rate for grass for toddlers (age 3 years) was 25 cm2/day. This value is intended to represent the approximate area from which a child may grasp a handful of grass.

3.4.3.4 Residential Postapplication Risk Characterization

The detailed results of the residential postapplication exposure/risk assessment for short-/intermediate-term endpoints are presented in the following sections . Dermal MOEs are above 100 for all scenarios, and combined dermal and inhalation risks for applicable scenarios are all above 100, and do not trigger HED concern for postapplication residential (bystander) exposure in areas nearby fields being treated for boll weevil.

3.4.3.5 Postapplication Risk from Dermal Contact and Incidental Ingestion

The following tables show assumptions, calculations and results for the assessment of dermal contact to adults and children with residues on turf, and incidental ingestion by toddlers of residues on grass and soil following aerial ULV treatment of cotton for boll weevil in a nearby field.

Table 20: Residential Short- and Intermediate-Term Postapplication Scenarios and Estimated Risks for Malathion

Scenario	Crop or Target	Receptor	Application Rate Per Treatment (AR) (lbs ai/sq ft)[a]	TTR (ug/cm^2)[b]	Grt (ug/cm^2)[c]	Srt (ug/g)[d]	Transfer Coefficient (Tc) (cm^2/hr)	Exposure Time (ET) (hrs/day)	Dermal Abs. (%)	Surface Area (SA) (cm^2/ event)	Freq. (FQ) (events/ hr)	IgR (cm^2/day) or (mg/day)[e]	BW (kg)	ADD (mg/kg/day)[f]	MOE[g]
Dermal exposure	Turf (from aerial ULV spray-drift)	Adult	0.000021	0.054	-	-	14,500	2	100	-	-	-	70	0.022	2300
		Toddler					5,200						15	0.037	1400
Hand-to-Mouth	Turf (from aerial ULV spray-drift)	Toddler	0.000021	0.20		-	-	2	-	20	20	-	15	0.0110	4500
Turfgrass ingestion	Turf (from aerial ULV spray-drift)	Toddler	0.000021	-	0.054	-	-	-	-	-	-	25	15	9.0e-05	600,000
Incidental soil ingestion	Turf (from aerial ULV spray-drift)	Toddler	0.000021	-	-	2.76	-	-	-	-	-	100	15	1.8e-05	3.0E+6

Footnotes:

a Application rate: (air ULV) 0.9 lb ai/A)/43,560 sq. ft. per A

b Turf transferrable residue (ug/cm^2) = AR (lbs ai/ft^2) * fraction ai retained on foliage (1.3%, except 5% for hand-to-mouth) * 0.40 for air ULV * 4.54E+8 ug/lb * 1.08E-3 ft^2/cm^2.

c Grass residue (ug/cm^2) = AR (lbs ai/ft^2) * fraction ai retained on foliage (1.3%) * 0.40 for air ULV * 4.54E+8 ug/lb * 1.08E-3 ft^2/cm^2.

d Soil residue (ug/cm^2) = AR (lbs ai/ft^2) * 0.40 for air ULV * 4.54E+8 ug/lb * 1.08E-3 ft^2/cm^2 * 0.67 cm^3/g soil.

e Ingestion rate: cm^2/day for grass ingestion, and mg/day for incidental soil ingestion.

f Average daily dose (ADD) (mg/kg/day)

Dermal exposure: = DFR (ug/cm^2) * Tc (cm^2/hr) * mg/1,000 ug * ET (hrs/day) * absorption factor (1.0) / [BW (kg);

Hand-to-mouth: = DFR (ug/cm^2) * SA (cm^2/event) * FQ (events/hr) * mg/1,000 ug * ET (hrs/day) * 0.5 (saliva extraction) / BW (kg);

Turfgrass ingestion: = GRt (ug/cm^2) * IgR (cm^2/day) * mg/1,000 ug / BW (kg); and

Incidental soil ingestion: = SRt (ug/g) * IgR (mg/day) * g/1,000,000 ug / BW (kg).

g MOE = NOAEL (50 mg/kg/day) / ADD.

3.4.3.6 Postapplication Risk from Inhalation

The approach is based on the one described in the Draft Standard Operating Procedures (SOPs) for Residential Exposure Assessment for inhalation exposure to outdoor residential short-term pest control. The major difference is that the SOPs begin by assuming the use of a commercial fogger product that has a known volume. In the scenario below, the beginning assumption is that the percent of the aerial ULV application rate predicted by the AgDrift Model to be deposited (as above for dermal exposure estimates) is available in the breathing zone of the residential bystander. Thus the deposition rate expressed as lbs. ai/ft^2, (to which a dilution factor is applied per Draft Residential SOPs) is now considered to be a concentration expressed on a per cubic foot (ft^3) basis. The following is a stepwise process, including assumptions and calculations for estimating residential bystander inhalation exposure from aerial ULV treatment of the boll weevil.

The following inputs, assumptions, and calculations were used to estimate inhalation exposure and risk resulting from aerial ULV applications to treat boll weevils:

Inputs and Assumptions

- Aerial ULV application rate is 0.9 lb ai/acre
- Deposition rate over distance of 75 feet beyond edge of treated field = 40% of application rate
- Dilution of airborne concentration of 1 to 100 (i.e., 1 percent (0.01) of product released is available for exposure
- Adult breathing rate = 0.55 m^3/hour, and weight is 70 kg; toddler breathing rate = 0.36 m^3/hour, and weight is 15 kg
- Exposure time is 20 minutes (0.33 hours)
- Target MOE = 1000
- Short- and intermediate-term Inhalation LOAEL = 25.8 mg/kg/day

Calculations for short- and intermediate-term risk

- Application rate of 0.9 lb ai/acre x 1 acre/43,560 ft^2 = 0.00002 lbs ai/ft^2
- Deposition rate = ~ 40% of application rate at 75 feet from edge of treated field = 0.0000083 lbs ai/ft^2
- Expressed as an airborne concentration = 0.0000083 lbs ai/ft^3
  0.0000083 lbs ai/ft^3 x 35.3 ft^3/1 m^3 = 0.00029 lbs ai/m^3
  0.00029 lbs ai/m^3 x 454,000 mg/lb = 131.66 mg/m^3
- Application concentration (131.66 mg/m^3) x dilution factor (0.01) = 1.32 mg/m^3
- $Dose_{adult}$ = (concentration) x (breathing $rate_{adult}$) x (exposure duration) ÷ BW_{adult}
  = (1.32 mg/m^3) x (0.55 m^3/hour) x (0.33 hours/day) ÷ 70 kg = 0.0034 mg/kg/day

- Short- and Intermediate-term $Risk_{adult}$ = MOE = $LOAEL_{inhal}$./$Dose_{adult}$
= (25.8 mg/kg/day)/(0.0034 mg/kg/day) = 7600

- $Dose_{toddler}$ = (concentration) x (breathing $rate_{toddler}$) x (exposure duration) ÷ $BW_{toddler}$
  = (1.32 mg/m^3) x (0.36 m^3/hour) x (0.33 hours/day) ÷ 15 kg = 0.010 mg/kg/day

- Short- and Intermediate-term $Risk_{toddler}$ = MOE
= (25.8 mg/kg/day)/(0.010 mg/kg/day) = 2600

3.4.3.7 Non-occupational Combined Exposure/Risk

In Table 21 below, the exposures from inhalation of malathion during treatment of a nearby field are added to the risk from dermal contact with residues on turfgrass. This combination of exposures is believed to be the most likely, worst-case scenario. Reasonable upper bound assumptions are included in the estimate, including that the area of concern is only 75 feet from the treated field; that the bystander is standing in the area for 20 minutes during active spraying; that the bystanders are engaged in high-contact activities on the turf for 2 hours on the day of spraying.

Table 21. Combined Postapplication Inhalation and Dermal Risk Following Boll Weevil Treatment

Scenario	Application Rate	Crop Type or Target	Dermal Daily Dose (mg/kg/day)	Dermal MOE	Inhalation Daily Dose (mg/kg/day)	Inhal. MOE	Total MOE
Adult							
Postapplication Inhalation and Dermal Contact with Turf Following Aerial ULV Boll Weevil Treatment	0.000021 (lb ai/sq ft)	Cotton Boll Weevil Eradication	0.022	2300	0.0034	7600	1800
Toddler							
Postapplication Inhalation and Dermal Contact with Turf Following Aerial ULV Boll Weevil Treatment	0.000021 (lb ai/sq ft)	Cotton Boll Weevil Eradication	0.037	1400	0.010	2600	900

3.4.3.7 Residential Postapplication Monitoring Data

Several environmental monitoring studies were conducted by the USDA Animal and Plant Health Inspection Service (APHIS) to assess the potential for human exposure to aerially applied malathion from the USDA Boll Weevil Eradication Program.

In a 1995 report on the Southeast Boll Weevil Eradication Program[12], data were collected on the dermal and inhalation exposure on two different days at two residential houses when nearby cotton fields were treated aerially by malathion. The houses were 3 miles apart; one was 150 feet away from the edge of the treated field; the other 75 feet away. Both downwind and upwind conditions were captured. A roto-rod air sampler was placed 25 feet from the houses to quantitatively measure airborne droplets of malathion in the size range of 10 to 100 microns in diameter. Other air sampling devices with a glass fiber filters and air sampling pumps were placed both inside and outside windows of the houses. Individuals observing the aerial application were fitted with 4x4 gauze pads on their chest, upper arms and legs and with personal air sampling devices to assess dermal and inhalation exposure, respectively. Baseline and 48-hour postapplication blood samples were collected and analyzed for plasma and red blood cell acetylcholinesterase (AChE) levels. These individuals were considered to be part of the worker population, and not residential bystanders.

The above monitoring study found that almost all air samples taken in and around residential houses were below the limit of detection (i.e., <5.0 nanograms for the roto-rods, and <2.42E-6 mg/m^3 for the glass fiber filters). Only the roto-rod instrument detected malathion; the largest concentration being seen in the first hour following treatment at one house, on one day (0.02 mg/m^3). All personal breathing zone samples were below the limit of detection (i.e., <0.001 mg/m^3). Gauze pad data indicated the highest dermal exposure to be 1.56 mg/m^2. For all monitored individuals, there were no changes in either plasma or red blood cell AChE levels.

In a 1998 Environmental Monitoring Report on the Boll Weevil Eradication Program in Alabama, Arkansas, Lousiana, Mississippi, and Tennessee[13], the possibility of human exposure to spray drift following aerial application of malathion near sensitive sites, such as residences, public buildings, and schools, was monitored. To do this, three pairs of dye cards were placed between residences, churches, schools, etc., all within 500 feet of the treated cotton field. Cards were placed 30 minutes prior to spraying and were left exposed during treatment and for two hours thereafter. Dye cards with visible spots were sent to the APHIS National Monitoring and Residue Analysis Laboratory for residue analysis. Negative controls were prepared, but positive or spiked controls were not. In all, dye card monitoring was done near 31 sensitive sites during a total of 80 aerial applications. Some sites were monitored for as many as 9 Program-applied treatments. No visible spots were present on 36 of the 80 applications (possibly due to wind direction away from sensitive sites). Of the dye cards on which drops were visible, the measured, residue levels ranged from below the limit of detecction (<0.3 mg/m^2) to 30 mg/m^2, with the median value of 3.5 mg/m^2 and the mean of 5.1 mg/m^2. The median and mean values represent 2-4% and 4-6% depositon rates, respectively. Only 13% of the droplet spectra for ULV malathion as applied by the BWEP is in the respirable size range of 1-100 microns (Mierzejewski and Hewitt, 1993).

Dermal exposure and changes in blood AChE levels in agricultural workers, were monitored by fitting four employees of the Program with gauze patches during five full work days and collecting blood samples on a periodic basis (baseline, through

the treatment program season, and two to three weeks following the last treatment of the program). No changes were seen in AChE levels in any of the workers monitored.

In a 1998 Environmental Monitoring Report on the Boll Weevil Eradication Program in Texas[14], dye cards and monitoring of AChE levels in workers were used as in the above studies to determine potential exposure to sensitive areas nearby to aerial boll weevil control operations. There were 223 fields near sensitive sites which were sprayed a total of 1,147 times, ranging from 1 to 18 times (average of 5.1 sprays per field). On 30 occasions, visible spotting occurred. Quantitative analysis of cards with visible spotting was not conducted, but most were qualitatively described as having very few or very light spotting. On average, changes in cholinesterase levels (both above and below baseline) were less than 8.5%, with nearly all individuals within 20% of baseline.

3.4.3.8 Occupational Exposure Data for OPPTS Guidelines

Additional foliar dislodgeable residue data for crops other than turf are needed to further refine the risk estimates for restricted entry intervals (REIs) for malathion.

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